HIGHWOOD WATER MANAGEMENT PLAN, PHASE 1

Public Advisory Committee
Final Report, June 2006

Meeting Community Water Needs
& Protecting Aquatic Habitats

Volume 1

REPORT AND RECOMMENDATIONS
FOR
HIGHWOOD DIVERSION PLAN

Highwood Water Management Plan, Phase 1
Public Advisory Committee Final Report, June 2006

Volume 1

Report and Recommendations for Highwood Diversion Plan

Technical Background Summarized by:

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Public Advisory Committee Declaration of Agreement

We, the undersigned, are the designated members of the Highwood Water Management Plan Phase 1 Public Advisory Committee (PAC). We represented interested community groups and municipalities in a public process that led to unanimous agreement on the recommendations presented in this report for the development of a Highwood Diversion Plan. On this date, June 6, 2006 we respectfully request that our PAC Chairman, Shirley Pickering, submit this report to Alberta Environment with the request for a timely response.

Community Groups	Representatives
Baker Creek/Women's Coulee	Stephen Evans (member)
Fisheries Coalition	Alan Harvie (member)
Lower Little Bow River	Malcolm MacDougall (member)
Lower Mosquito Creek	Diana Andrews (member) Diana Andrews
Stimson Creek	Barbara Gardner (member) Barbara Gardner
Upper Little Bow River	Lucille Akitt (member)
Municipal Entities	
Towns/Municipalities within the County of Vulcan	Merle Wyatt (alternate member)
MD of Willow Creek & Town of Stavely	Ian Sunquist (member)
Town of Nanton	Bill Szabon (member)
MD of Foothills	Roy M^cLean (member) Roy R. McLean
Town of High River	~~Frank Van Donzel~~ (alternate member) Floyd [illegible] (member)

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3. Fact Sheet: Livestock Water Use (Hart 2004)
4. Fact Sheet: Current Actual Water Use (Hart 2004)
5. Technical Note: Natural Flow Database and Model Configuration (Hart 2004)
6. Fact Sheet: Computer Simulation Modelling (Hart 2004)
7. Scenario Construction and Priorities (Czarnecki 2004)
8. Fact Sheet: Drought Period Operation Procedures (Hart 2004)
9. Review of Additional Storage (Middleton 2004)
10. Technical Note: Future Water Demand Projections (Hart 2004)
11. Fact Sheet: Historical Review of Moratoria and Diversion Rules for the Highwood/Little Bow System (Hart 2004)
12. Fact Sheet: Highwood River Aquatic Protection and Diversion Rules (Hart 2004)
13. Report on Public Consultation Efforts and Results: October to December 2004 (Equus Consulting Group 2005)

Acknowledgements

To a large extent, this report is the end product of the collaborative efforts of Public Advisory Committee, Alberta Environment, Alberta Infrastructure and Transportation and several consultants. A large measure of the credit for the study process goes to the Management Sub-committee of the PAC, comprised of:

Shirley Pickering, Chair
Harry Riva Cambrin
Diana Andrews
Bill Szabon
Stephen Evans
Gerald Porter

The entire Public Advisory Committee contributed to the recommendations contained in the Executive Summary of the report. The recommendations are theirs. Public input received at the open house meetings helped to refine the recommendations.

Numerous government employees contributed to the study effort; outstanding among them were:

Kent Berg, Alberta Environment
Tom Tang, Alberta Environment
Andrea Czarnecki, Alberta Environment
Ron Middleton, Alberta Infrastructure and Transportation

The Public Advisory Committee recognizes and thanks Dick Hart for the valuable service and expertise he brought to the PAC technical team, and for documenting and summarizing effectively the technical work done to support the recommendations in this report.

Executive Summary and Recommendations

Introduction

The Highwood Water Management Plan, Phase 1 Public Advisory Committee (PAC), is composed of volunteers representing members from municipalities, industry, and local water user interest groups in the Highwood and Little Bow basins. The PAC was formed in 2001 under the guidance of Alberta Environment to advise on the development of a revised Highwood Diversion Plan. The PAC process was community driven and collaborative, with PAC subcommittees, government staff, and expert consultants working closely together during data collection, scenario development, and evaluation. The subcommittees also sought community input on specific issues at various stages of the process through consultation with the broader membership of basin water user groups.

Scenarios were developed and evaluated in an effort to find the best balance between water consumption (e.g. municipal, industry, irrigation, stock-water) and environmental protection (e.g. fish habitat, water quality, riparian habitat) while staying within current water regulations. In 2004 the PAC reached a consensus agreement on a preferred scenario that provided this best balance.

In this report PAC recommends the provisions of the preferred scenario as the basis for the development of a revised Highwood Diversion Plan. A series of contingent measures required for implementing the plan and verifying its performance are provided as an inherent part of this recommendation. The PAC also makes recommendations to improve future water management in the Highwood/Little Bow Basins.

Background

The Little Bow Project/Highwood Diversion Plan proposed by Alberta Infrastructure and Transportation in 1995 included a set of priorities and operating rules for the existing and proposed water management structures in the basins, including:

- The existing Women's Coulee Diversion.
- The existing Women's Coulee Dam.
- The expanded Little Bow Diversion.
- The new Twin Valley Dam (formerly Little Bow River Dam).
- The new Clear Lake Diversion.

This set of operating rules was referred to as the **Highwood Diversion Plan**.

The proposed structural developments and the Highwood Diversion Plan were reviewed at the Natural Resources Conservation Board/Canadian Environmental Assessment Agency Joint Review Panel hearing in late 1997 and early 1998. In its May 1998 decision report (NRCB/CEAA Joint Review Panel, 1998), the Panel:

- Approved the construction and operation of the Clear Lake Diversion, as proposed.
- Approved the construction and operation of the Twin Valley Dam, as proposed.
- Approved the expansion of the Little Bow Diversion, as proposed.
- Approved operation of the Little Bow Diversion as proposed for all but the late July and August period.
- Reserved decision on the operation of the Little Bow Diversion for the late July and August period pending receipt of information as prescribed in NRCB Board Order 9601-1.

The Panel had three major concerns regarding the proposed diversion plan:

- It did not respect existing licensed commitments along the lower Highwood River and in the Little Bow River Basin.
- It would result in significant negative impacts to the water quality in the upper Little Bow River and lower Mosquito Creek.
- It did not adequately meet the Government of Alberta's fisheries objectives for the Highwood River.

The Panel believed additional water storage was required in the Highwood River basin to address these concerns and ordered Alberta Infrastructure and Transportation to conduct further studies of the potential for, and impacts of, the development of storage. The Panel also required revision and update of the instream flow needs (IFN) assessment for the Highwood River to reflect current fishery management objectives and the current information base and scientific procedures (NRCB Board Order 9601-1).

All structural components of the Little Bow Project have now been constructed and are operating under an Interim Operating Plan filed by Alberta Infrastructure and Transportation in October 2002 (revised in March 2004).

Alberta Environment (AENV) and Alberta Infrastructure and Transportation (AI&T) have been working toward development of a revised diversion plan under the guidance and direction of the Highwood Water Management Plan Public Advisory Committee (PAC). Computer simulation modelling was the primary analytical tool used to test numerous operating scenarios. The PAC established a Modelling Focus Group, a sub-committee of the PAC, to work with Alberta Environment and Alberta Infrastructure and Transportation.

The scenarios for an operating plan considered the objectives established by the Joint Review Panel, the technical Highwood River instream flow needs recommended by the Instream Flow Needs Technical Working Group[1], and the findings of Alberta Infrastructure and Transportation with regard to new storage development in the Highwood River Basin. Numerous water management options have been tested using a computer simulation model. Each option (or scenario) was evaluated using performance indicators and criteria (table below). An over-riding criteria established by the PAC was that no pre-project water users (consumptive and non-consumptive) would be negatively impacted. Comparison of scenario performance with pre-project performance or the Base Case was a key evaluation component.

A scenario that has been judged to meet the objectives of the Highwood/Little Bow Project, to the extent possible, has been developed. The PAC recommendations in this report include a scenario that would provide the basis for developing the Highwood Diversion Plan, and measures required for implementing the plan and verifying its performance. This report also includes recommendations of the PAC that will improve water management in the study area. These recommendations came to light in the course of work on the Highwood Diversion Plan.

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[1] Instream Flow Needs Technical Working Group: a group of fishery experts brought together by Alberta Infrastructure and Transportation in 1998 to review the existing instream flow needs analysis and provide a scientific determination of the instream flow needs for the Highwood River. This study was done in response to Condition 6 of NRCB Board Order No. 9601-1.

Performance parameters and criteria.

Issue	Indicator Parameter	Measure	Criteria
Consumptive Uses	Irrigation deficits	% of years deficits > 100mm. Time series of demands and deficits.	Deficits ≤ pre-project conditions. No back-to-back deficits > 100 mm. Comparative analysis.
Aquatic Ecosystem Health	Fish habitat	Overall average habitat. July 16 to Aug 31 average habitat. Max yearly reduction from natural Max weekly reduction from natural	Habitat ≥ Base Case habitat. Comparative analysis
Water Quality	Minimum flow indicators	Highwood T* and DO* flow ≥ 8.0 m^3/s. Upper L. Bow DO flow ≥ 1.11 m^3/s.	Comparative analysis.
Riparian Vegetation	River stage patterns.	River stages and down-ramping for regeneration, survival and growth.	Comparative analysis.

*T = Temperature; DO = Dissolved Oxygen

Objectives of the Highwood Diversion Plan

The Joint Review Panel directive outlining the objectives of the Highwood Diversion Plan is provided in the 1998 Decision Report.

> *"...the objectives of the revised diversion plans should be to ensure that the science-based IFN is observed in the Highwood, that existing licence commitments are upheld, that adequate conveyance flows are maintained in both the upper Little Bow River (30-40 cfs) and lower Mosquito Creek (20-30 cfs), that known future demands can be met, and that consideration is given for reserving water, if possible, for future requirements that are unknown at this time."* (Joint Review Panel 1998; page 9-2).

The PAC added one more objective: conditions for pre-Little Bow Project water users, consumptive or non-consumptive (including aquatic ecosystem health and fish habitat), would be sustained or improved under post-project conditions.

From the outset, the PAC recognized that meeting all of these objectives without additional storage would not be possible. For example, during periods of low flow there would continue to be conflicts between Highwood River instream flow needs and pre-Little Bow Project licence commitments. PAC worked to find the best balance between supply and demands to minimize such conflicts. At the same time, efforts were made to meet the new commitments of the approved Little Bow Project and adhere to existing water resource regulations and policies. To do this PAC came up with a modelled compromise scenario that provided this balance without additional storage. New storage, the Super Expanded Women's Coulee Reservoir, was then added to the preferred scenario to assess improvements in scenario performance toward meeting the objectives. The value of new storage was assessed in this manner.

The PAC makes the following recommendations for the development and operations of a new Highwood Diversion Plan based on the assessment of over 60 scenarios.

Recommendations

1. Highwood Diversion Plan Without Additional Storage

It is recommended the Highwood Diversion Plan be developed based on the attributes of Scenario IDP8CS1, which does not include additional storage in Highwood basin. Details of the storage assessment are found in the Fact Sheet: Review of Additional Storage (Middleton 2004; Compendium). The key attributes, priorities and performance of Scenario IDP8CS1 are outlined in Chapter 5.0 of this report. An Alberta Environment operations report (draft) on the proposed Highwood Diversion Plan (HDP), based on Scenario IDP8CS1, is available as a separate document.

The Public Advisory Committee determined that the proposed HDP meets the objectives of the Highwood/Little Bow Project to the extent possible without negatively impacting pre-project water users, including the lower Highwood River fishery, and without additional storage development. The additional storage development investigated (Super Expanded Women's Coulee Reservoir) did not result in sufficiently improved performance of Scenario IDP8CS1 to justify its high cost and its social and environmental disruption.

Contingent measures or strategies for implementing and operating the Highwood Diversion Plan are essential and inseparable from the diversion plan itself. These are as follows.

1.1 Irrigation Licences with July Cut-offs

It is recommended pre-Little Bow Project irrigation licensees holding licences with July cut-offs be given a two-year opportunity to apply for removal of the cut-off by licence amendment.

In actual operation of the Highwood/Little Bow system, the irrigation licensees with July cut-offs were often granted extensions to continue irrigation after the cut-off date when the 1994 Guidelines for Highwood River Diversion and minimum operating flow targets on the Little Bow River and Mosquito Creek could be met. Scenario IDP8CS1 recognizes this water management practice by removing the cut-off date, subject to the 1994 Guidelines and to minimum operating flow targets of 0.850 m^3/s (30 cfs) along the Upper Little Bow River, 0.566 m^3/s (20 cfs) along the Lower Little Bow River, and 0.283 m^3/s (10 cfs) along Mosquito Creek. The modelling showed that irrigation performance improved over pre-project performance for these licences, and that pre-project protection of the Highwood River fishery was maintained. In addition, making post-cut-off date irrigation withdrawals subject to minimum operating flow targets would alleviate the potential for instream flows in the Little Bow Basin being drawn down to near zero in late summer.

It is recommended that licensees be given the opportunity to permanently remove the cut-off date, subject to the instream conditions. There would be no change in the licence allocation or change in the priority and administration of the licences for water use prior to the cut-off date. To simplify administration and operations, it is recommended that those licensees who choose not to apply for removal of the cut-off not have their cut-offs extended in future years, regardless of the water supply situation in the Highwood and Little Bow Basins.

It is recommended that notice of this window of opportunity be forwarded to the licensees, along with application forms for amendments. It is suggested that a reminder be sent out to those licensees who had not submitted an application within one year of the first notice.

1.2 Performance Monitoring for Adaptive Management

It is recommended that a monitoring program and performance assessment strategy be developed and implemented to evaluate the effectiveness of the Highwood Diversion Plan in achieving the water management objectives and to provide a basis for adaptive management of the system.

Commitments to completing the monitoring programs and providing timely interpretations must be adhered to and carried out in consultation with a core group of the Phase 1 HWMP-PAC to assure timely, responsible and accountable adaptive management decisions. The monitoring agency should report to the core group on a regular basis, at least annually, on the status of the monitoring program and future plans.

The PAC's work required updating the water demand and supply databases to establish performance criteria for the existing diversion operations (Base Case). This task was made difficult and often thwarted by information gaps resulting from incomplete or outdated monitoring programs. Where monitoring programs were done, documentation of results was often incomplete or lacking.

The new proposed diversion plan will impose flow regime changes along the streams. Accurately predicting the response of the complex ecosystems in the Highwood and Little Bow River Basins to these changes is clearly beyond the capability of the Public Advisory Committee and its advisors. As well, the reliability of the real operation of this plan to meet water management objectives defined in the modelled scenario has yet to be performance tested. This led to the PAC adopting the concept of adaptive management. Adaptive management requires an ability to identify and monitor parameters affecting performance, and to respond to unsatisfactory performance with corrective actions.

Systematic monitoring and assessments will enable validation of the operation guidelines, or identification of areas where operational refinements are required to minimize negative impacts on the environment and the consumptive users. Performance monitoring and assessment is recommended in the areas of water quality, riparian habitat, Highwood fishery criteria, and water use, as noted in Recommendations 1.2a to 1.2d.

Simulation modeling has shown that there is very little flexibility in the operation of the Highwood diversion structures. The differences in flows among the scenarios tested are small. A key issue is the relationship between fish habitat in the lower Highwood River, and water quality in the Upper Little Bow River and Mosquito Creek. The Joint Review Panel recommended a minimum flow of 0.85 to 1.13 m^3/s (30 to 40 cubic feet per second) during the operating season. Preliminary water quality analyses suggest that at least 0.85 m^3/s (30 cfs) was required to maintain adequate water quality to protect fish in the Upper Little Bow River. A minimum flow of only 0.57 m^3/s (20 cfs) is currently being used in the preliminary operating plan. Questions related to this issue include:

- What is the minimum flow required to protect water quality in the Upper Little Bow River and Mosquito Creek, and for what period during the operating season?
- Does a difference of 0.28 to 0.57 m^3/s (10 to 20 cfs) in diversions from the Highwood River significantly affect fish movement or habitat in the Highwood River?

- Efforts to fine-tune the recommended scenario led to the testing of several scenarios that showed little difference in the flows diverted to the Little Bow River Basin and the flows remaining in the Highwood River. Small changes in flows can have significant water quality benefits in the Upper Little Bow and Mosquito Creek. Do the differences in Highwood River flows among various scenarios significantly affect water quality, fish movements, fish habitat and fish populations in the Highwood River?

Development of a performance-monitoring program will require:

- Identification and co-ordination of existing monitoring programs to identify deficiencies.
- Establishing monitoring purpose, protocols and parameters (e.g. locations, timing, frequency and durations of monitoring, analytical techniques, etc.).
- Establishing the agencies and work units responsible for the monitoring and assessment.
- Preparing and reviewing interpretation reports of monitoring results on a timely basis.
- Advising the project operators and the public advisory committee(s) of findings and suggestions for operational changes.

1.2a Water Quality Monitoring

It is recommended that AENV review existing water quality monitoring in the Highwood and Little Bow River Basins by all parties (Provincial and Federal Governments, industry, communities, rural municipalities, Ducks Unlimited, Trout Unlimited, etc), and develop a comprehensive, co-coordinated plan to provide a database for addressing a number of issues, including:

- **Frank Lake water quality impacts on the Little Bow River and Twin Valley Reservoir.**
- **Upper Little Bow water quality for maintenance of the aquatic ecosystem and protection of municipal, domestic, stock water, and irrigation water supplies.**
- **Mosquito Creek water quality for the protection of municipal, domestic, stock water, and irrigation water supplies. The new flow regime has significantly increased turbidity in Mosquito Creek.**
- **Determining the water quality suitability of the Twin Valley and Clear Lake Reservoirs for their respective multi-purpose uses (e.g. recreation, irrigation, source for raw drinking water, fishery).**
- **Highwood River water quality for maintenance of the aquatic ecosystem and protection of municipal, domestic, stock water, industrial and irrigation water supplies.**

Water quality monitoring requirements must be specified in detail and tied to specific objectives. Monitoring must be coordinated and efficient. Completing the monitoring program and providing timely interpretations are required.

1.2b Highwood River Fishery Water Temperature and Dissolved Oxygen Operating Criteria

It is recommended that AENV undertake monitoring and analyses to determine the appropriateness and effectiveness of the temperature and oxygen criteria in the 1994 Highwood River Diversion Guidelines and associated operating and monitoring procedures. It is recommended that an assessment be carried out to determine whether or not changes in the diversions triggered by the temperature and dissolved oxygen criteria have had the desired impact on Highwood River water quality.

Temperature criteria were added to Highwood River Diversion Guidelines in 1986, and dissolved oxygen criteria were added in 1990. It was the understanding of some of the Little Bow water users that acceptance of temperature and oxygen criteria in the Highwood Diversion Guidelines was on condition that they would only be temporary constraints until measures were in place to alleviate water deficits. In the 1997/1998 EIA Hearings conducted by the Joint Review Panel, there was considerable discussion of the validity of the temperature criteria, and whether or not the resulting improved fish habitat conditions justified the negative impacts on water users in the Little Bow River Basin. Analysis and discussion was hampered by a lack of data and concrete evidence that cutbacks in diversions significantly improved Highwood River temperature conditions. Furthermore, temperature driven operations of multi-day on-again, off-again diversion cutbacks cause significant operational problems for Little Bow basin water users, as well as negatively impacting water quality and the re-stabilization of riparian vegetation along the upper Little Bow River. Dissolved oxygen has not been a constraint since 1989 when treated effluent from the Town of High River was discharged to Frank Lake rather than to the Highwood River.

The validity and effectiveness of the temperature and dissolved oxygen constraints in the 1994 Highwood River Diversion Guidelines and the associated operating and monitoring procedures need to be re-examined.

1.2c Riparian Habitat

It is recommended efforts be made to operate the Little Bow Diversion works in a manner that fosters a healthy riparian environment along the Upper Little Bow River (Rood et al, 2002 and 2002A). It is recommended that AENV develop and implement a monitoring and management program that tracks geomorphologic and riparian vegetation changes along the Upper Little Bow River.

It is predicted there will be geomorphologic changes along the Upper Little Bow River as the channel size and shape adjusts to the new flow regime. Once equilibrium has been reached, it has been projected there could be significant improvement in the potential for establishing and maintaining riparian vegetation. However, these predictions are not certain.

A monitoring and management program would identify and evaluate changes that occur, recommend required refinements to the operating procedures for the diversion works, and identify land use practices that would assist in establishing and maintaining a healthy riparian ecosystem. This would improve prospects for optimizing riparian benefits of the new flow regime, and minimizing the negative impacts.

Riparian conditions along the Highwood River and Mosquito Creek are not expected to change significantly under post-project flow regimes. Riparian habitat improvement programs are underway in the study area. These programs should be continued, and expansion to other areas should be encouraged.

1.2d Water Use Monitoring and Reporting

It is recommended that AENV develop and implement a simple water use monitoring and reporting system to record the annual and seasonal variations in water uses and return flows in the Highwood and Little Bow River Basins. Improved monitoring and reporting is required to assist in planning, operations and enforcements.

Most licences require the water user record and report annual water use to AENV. These licence conditions have not been consistently enforced. The records that have been received by AENV have not been compiled and analyzed in recent years. Compiled, systematic water use records combined with adequate instream flow monitoring data would greatly assist in water management planning, operating the project and enforcement.

Many municipalities and industries currently record water use and return flow. For irrigation users, at a minimum, a simple time on/time off recording procedure and the pump rating would provide a valuable record. Water use return cards and clear instructions should be developed by AENV for the convenience of the user. On-line, electronic reporting is an option that should be considered.

1.3 Communications

It is recommended AENV work with the water users to develop a communications system to improve the operator's ability to match water deliveries with water demands and to reduce impacts of irregularities in diversion operations.

Monitoring and reporting should be supported by good communications between operators and water users, because operators do not have perfect knowledge of water supply or demand. Users should be kept informed of operations and be alerted to irregularities, or potential irregularities, through local contact people.

In an open channel system it is not possible to perfectly match water supply with water demands. However, good communications between operators and water users will help to minimize over-deliveries due to uncertainties in day-to-day water demands, and help to make more efficient use of the water supply. Irrigation districts in southern Alberta have worked out water ordering procedures that could possibly be adapted to improve operational efficiency in the Highwood/Little Bow system (Appendix B). It is believed that a similar system developed in consultation with the irrigators would improve the supply-demand efficiency of the diversion system. Electronic communications should be considered.

1.4 Enforcement

It is recommended AENV enforce the allocations, and terms and conditions of licences and temporary licences in the Highwood and Little Bow River Basins.

The modeling results indicated many irrigation projects are under-allocated for the types of crops now grown. The farm gate demand for the types of crops grown exceeds the licence allocation in many years. PAC recommendations are based on modelling results assuming diversions cease when the full allocation has been withdrawn from the source stream. Periodic, random water audits should be conducted to ensure users are not diverting in excess of their licence allocations.

AENV administrators should be receptive to, and encourage water rationing and deficit sharing in times of deficits rather than strict adherence to the priority system. However, in the absence of a sharing arrangement, the priority system should be enforced.

Issuing temporary licences and the use of such licences requires improved compliance scrutiny. No temporary diversions should have priority over licensed uses or instream minimum flow requirements except possibly for municipal emergency use.

1.5 Role of Core Advisory Body from the Phase I Public Advisory Committee

It is recommended that AENV recognize a role for, and establish as an entity, a core group of the current Public Advisory Committee for the following purposes:

- **Oversee the timely implementation of the recommendations presented herein. Progress reports, prepared by Alberta Environment, on each and every recommendation should be provided to the core group at least once a year.**
- **Report to the Phase II PAC on Highwood Diversion Plan performance monitoring.**
- **Act as a sounding board for AENV administrators to test various ideas and options for implementation.**
- **Provide continuity and input to AENV in the conduct of Phase II of the Highwood Water Management Plan.**
- **To work with the Phase II group on setting Water Conservation Objectives.**
- **Provide AENV with a point of contact for public notification of allocation transfer applications, licence and temporary licence applications, and other significant water management issues in the Highwood and Little Bow River Basins.**

The wealth of information and experience gained by the Phase 1 PAC over the past five years would be of great value in implementing the recommendations and continuing the planning program for the Highwood River/Little Bow Basins.

Recommendations considered by PAC to be important for future water management in the Highwood/Little basins are as follows.

2.0 New Storage Development

Simulation modeling showed that the Super Expanded Women's Coulee Reservoir would provide minimal benefits toward meeting the recommended technical instream flow needs (IFN) on the Highwood River. **It is recommended that development of the Super Expanded Women's Coulee storage site or any other similar major storage in the Highwood basin not be developed, pending further fishery field studies.**

The primary intended purpose of the Super Expanded Women's Coulee storage site would be to improve the aquatic ecology of the Highwood River. The storage performance study (Fact Sheet: **Review of Additional Storage** (Middleton 2004; Compendium)) shows no significant benefits to the Highwood River. The hydrology of the Highwood River and the new recommended technical IFN are such that there would be limited water available for diversion to storage without impinging on the IFN. In low runoff years, reservoir storage would be depleted and there would be no benefits when they are most needed. Also, the social and environmental disruption and high cost of the project also do not justify this concept. Other storage sites investigated by Alberta Infrastructure and Transportation in the 2001 storage option study were even less attractive than the Super Expanded Women's Coulee site (Alberta Infrastructure and Transportation 2001).

PAC is concerned with the large increase in water required to meet the recommended technical Highwood IFN in a basin where periodic water shortages are known to occur. The recommended technical Highwood IFN calls for substantially more water than the Fish Rule Curve-based approach originally proposed by the proponent for the Little Bow Project and reviewed in public hearings held by the Joint Review Panel. The PAC strongly believes that before consideration is given to any storage in the Highwood Basin there is need for a comprehensive fishery field study on the whole Highwood system including its tributaries to determine the value of this fishery, and the validity of its aquatic habitat requirements and the recommended technical IFN (Recommendation 8.0).

3.0 Licence for the Pre-project Little Bow Diversion

It is recommended a licence for the pre-project 2.83 m^3/s (100 cfs) Little Bow Diversion be issued to the Crown in the Right of Alberta Environment.

In 1898 the Government of the Northwest Territories applied for a licence to divert 1.42 m^3/s (50 cfs) from the Highwood River in NE 1-19-29-4 to the Little Bow River for domestic purposes. These works were licensed in 1905. In 1922, the Little Bow Irrigation District applied for a licence to divert from the Highwood River in NW 6-19-28-4, sufficient water for irrigation of 1335 ha (3300 acres) in the Little Bow River Basin. An Authorization was issued in the same year. The Little Bow Irrigation District (LBID) entered into an agreement with the Crown in 1922 whereby the LBID would operate its works to deliver the 1.42 m^3/s (50 cfs) entitlement of the Crown under the August 1905 licence, plus the flow required to meet the needs of its irrigators (an additional 1.42 m^3/s or 50 cfs, approximately). The troublesome government works in NE 1-19-29-4 were abandoned. The 1905 licence was not transferred to the LBID and was cancelled in 1977.

The LBID experienced financial problems. In 1950 an Order-in-Council dissolved the LBID and transferred ownership and operation of the works Authorized in 1922 to the Crown. The Order-in-Council recognized that the works were intended to serve domestic and irrigation needs. The Crown made necessary repairs and improvements to the works and assumed responsibility for operations. At that time, the Crown was not bound by the *Water Resources Act*. (In 1971 the *Act* was amended to bind the Crown. Prior to this, it was assumed that no licence was required for Crown-owned works.) The pre-Little Bow Project capacity of the diversion works was 2.83 m^3/s (100 cfs). The 2.83 m^3/s (100 cfs) diversion remains unlicensed.

Licensing the 2.83 m^3/s (100 cfs) pre-project diversion would clarify ownership and the rights that exist as a result of Crown assuming responsibility for the pre-project diversion in 1922. Priorities would be ascertained. Licensing the 2.83 m^3/s (100 cfs) diversion would provide a mechanism for clarifying operation of the diversion works and providing legal status for the portion of Highwood Diversion Plan that applies to the pre-project works.

4.0 Legal Status for the Highwood Diversion Plan

It is recommended the Highwood Diversion Plan be incorporated as an operation plan into Alberta Environment licences for the Women's Coulee and Little Bow Diversion works.

Incorporating the Highwood Diversion Plan into licences would give the plan legal status and a priority. Three licences would be involved: the Women's Coulee Diversion licence issued November 7, 1997, the Little Bow Diversion licence issued March 28, 2000, and a new licence proposed to be issued for the 2.83 m^3/s (100 cfs) pre-project Little Bow Diversion (Recommendation No. 3.0). Procedures for modifying the plan should be included as conditions on the licences. These conditions should be defined in consultation with the core group of the Phase 1 PAC. Modifications that significantly affect performance in meeting objectives should be subject to public review and appeal.

5.0 Licensing Post-Little Bow Project Water Use

It is recommended that AENV continue to license projects using water from, and downstream of, the Twin Valley Reservoir in accord with the application and priority system under the *Water Act*. Licensing should not be limited solely to irrigation; other uses to consider include municipal,

industrial and other (non-irrigation) agricultural uses. Total allocations for all uses shall not exceed the amount of water required for the irrigation of 6677 ha (16,500 acres).

Moratoria, with exempted uses similar to the existing moratoria, should be established under the *Water Act* for the Highwood River, Upper Little Bow River and Mosquito Creek. The moratoria should clearly state that licences for exempted uses, including temporary licenses, should be subject to the instream objectives for the Highwood River and the minimum operating flow targets for the Little Bow River and Mosquito Creek, consistent with the recommended Highwood Diversion Plan. The moratoria may be rescinded when Water Conservation Objectives have been established (Recommendation 8.0).

If real-time operation of the HDP is to be performance assessed it is important that instream guidelines be recognized in allocating new licensing, including temporary licenses. The documentation on the existing moratoria is sparse and unclear on instream conditions for licences issued under the exemption clause. The existing moratoria should be revised to clarify instream requirements. It is recommended that, in the future, licensing new water right applicants for any purpose be made aware of the risk (magnitude and frequency) of water supply deficits that can reasonably be expected. Informed applicants should be given the opportunity to withdraw their application, modify their project or proceed with the project as per their application.

6.0 Cancellation of Inactive Licences

It is recommended AENV cancel water licences that have not been used for a period of at least three years, and where there is no reasonable prospect for exercising the rights granted under the licence. The water should not be reallocated.

Unused allocated water creates a condition of uncertainty in a basin. If administrators do not know if or when the project will be activated, planning for economic growth and environmental protection is compromised.

It is essential that cancellations be implemented only where justified, and only after due process. Cancellations will be subject to appeal by the licensee.

7.0 Licence Allocation Transfers

It is recommended licence allocation transfers (entire or partial) of mainstem Highwood River, Mosquito Creek, or Little Bow River water be permitted only after review of factors listed in the *Water Act*, and under the following additional conditions:

Stream reaches are defined as:

- Highwood River – The entire mainstem river.
- Upper Little Bow – The mainstem stream from the Little Bow Diversion headgate to the upstream end of Twin Valley Reservoir, taken as Coal Mine Road (SSW2-16-26-W4).
- Lower Little Bow – The reservoir and mainstem river from Coal Mine Road to the upstream end of Travers Reservoir.
- Mosquito Creek – Includes Women's Coulee from the diversion headgate to its confluence with Mosquito Creek, and Mosquito Creek from the Women's Coulee confluence to the Mosquito Creek arm of Twin Valley Reservoir.

- **The seller and buyer are on the mainstem streams in the same sub-basin or stream reach (Highwood River, Upper Little Bow, Lower Little Bow and Mosquito Creek). For example, if the seller's licence is on Mosquito Creek, the buyer's licence should also be on Mosquito Creek.**
- **There is no adverse impact on environmental quality or other water users on the affected stream reach.**
- **Downstream transfers within the same reach are preferred, however, some upstream transfers within the same reach may also be acceptable where they have minimal instream and**

consumptive impacts and they provide for beneficial use. Transferring allocations from downstream of the Twin Valley, Clear Lake or Women's Coulee Reservoirs to upstream of those reservoirs would not be acceptable.
- **Transfers for like purposes would be preferred, however, a change of use purpose may be acceptable provided that the withdrawal period for the new licence is within the same withdrawal period for the original licence.**
- **A licence dependent upon stored water in Twin Valley, Clear Lake or Women's Coulee Reservoirs (including downstream projects) should only be transferred to a buyer who will be dependent on the same stored water. For instance, an allocation using water from Twin Valley Reservoir or downstream (Lower Little Bow reach) should not be transferred to a user upstream of the Twin Valley Reservoir (Upper Little Bow reach).**
- **Public input is always sought. To help facilitate public input, the core group of the Phase I PAC and all licence holders within the same reach should be advised of transfer applications by either AENV or by the applicant (as directed by AENV).**
- **Transfers that would increase post-HDP diversions from the Highwood River during drought conditions, when the Highwood Instream Objectives or Water Conservation Objectives are not being met, are unacceptable. Increased future diversions from the Highwood River beyond the diversions in Scenario IDP8CS1 during critical low flow periods would further encroach on the Highwood IO or WCO and should be avoided.**
- **Transfers to different water users should include a 10 percent holdback for the purpose of contributing to instream flow requirements. Transfers involving a licensee trying to improve efficiency of water use through relocation from one land location to a different but proximal land location owned by the same licensee should not include a holdback. Transfers of allocations that divert directly from a reservoir lake and that keep the new diversion point on the same reservoir should not include holdbacks as there is no instream benefit to be gained as along as the diversion remains on the reservoir.**

Water allocation transfers and holdbacks in the South Saskatchewan River Basin were approved in Phase I of the South Saskatchewan River Basin Water Management Plan (AENV 2002).

The primary objectives for permitting transfers in the Highwood/Little Bow study area are to provide an opportunity for new users or existing users requiring additional water to obtain a licence in these fully allocated basins, and to contribute to instream needs through holdbacks. It must be recognized that in the water-short streams of the Highwood/Little Bow River basins, a downstream licence allocation serves purposes beyond that of the licensee. A downstream allocation contributes to upstream flows, and improved water quality and riparian conditions. These benefits would continue if the transfers remain on the same mainstem reach. Downstream transfers within the same reach would enhance instream flow conditions and are therefore preferred. However, some upstream transfers within the same reach may also be acceptable. Transfers for like purposes would probably minimize impacts on the stream and other users, however, transfers for different purposes should not be ruled out where they have minimal instream and consumptive impacts, and provide benefits.

Allocations from a reservoir or downstream of a reservoir should not be transferred to a location that is upstream of storage.

8.0 Highwood River Water Conservation Objectives and Moratoria

It is recommended that establishing Water Conservation Objectives on the Highwood River, Upper Little Bow River and Mosquito Creek be further explored. In the meantime, it is recommended that moratoria, with exemptions similar to the existing moratoria, be established for these streams. The moratoria must ensure that licences for exempted uses, including approvals for temporary uses on

these streams, are subject to the same instream objectives and minimum operating flow targets that are inherent in the proposed Highwood Diversion Plan.

The PAC supports the concept of Water Conservation Objectives for protection of the aquatic environment of the streams, and as receptacles for licence transfers and holdbacks. The PAC recognized the recommended technical IFN in its efforts toward developing Scenario IDP8CS1 as the basis for the Highwood Diversion Plan. Every effort was made to minimize encroachments on the recommended IFN while attempting to meet other objectives of the project. However, the PAC is concerned about the large increase in flow requirements called for by the new technical Highwood IFN. Assigning a WCO that meets this IFN could shut down the basin for further water licensing in a community that is under increasing development pressure.

Some fishery experts and the PAC question the validity of the IFN assessment for Highwood because of the lack of supportive observed fish and related aquatic habitat data on the Highwood system (Highwood IFN, Peer Review, 2001). The PAC feels that it cannot assign a WCO to the Highwood River until the technical Highwood IFN has been validated or revised, and a more comprehensive and integrated approach to establishing WCOs in the entire Highwood/Sheep/Little Bow system has been undertaken. It is further recommended IFN investigations be given a high priority in Phase II of the Highwood Water Management Plan Study. In the meantime, moratoria should be established under the *Water Act* for the Highwood River Basin, Upper Little Bow and Mosquito Creek. Licences for exempted uses, including approvals for temporary uses, should be subject to Highwood River instream objectives and Little Bow River and Mosquito Creek minimum operating flow targets defined in the Highwood Diversion Plan.

9.0 Highwood Water Management Plan – Phase II

It is recommended AENV proceed with Phase II of Highwood water management planning. The Phase II study should include, but not be limited to:

- **An integrated and validated instream flow requirement study of major streams and tributaries in the Highwood/Sheep/ Little Bow system to assist in the establishment of instream Water Conservation Objectives.**
- **Track monitoring assessments on Highwood Diversion Plan performance.**
- **Sheep River water supply and environmental issues.**
- **Groundwater issues and the relationships between surface water and near-by groundwater.**
- **Continue investigations into non-storage water management options.**

The issues identified are those that have been raised by the PAC in the course of conducting the Phase I study on the Highwood Diversion Plan. They are not intended to be all-inclusive.

1.0 Introduction

1.1 Background

The Natural Resources Conservation Board (NRCB) and the Canadian Environmental Assessment Agency (CEAA) established a Joint Review Panel to review an application by the Alberta Government to construct the Little Bow Project and implement the Highwood Diversion Plan. Following a 19-day public hearing between November, 1997 and January, 1998, the Joint Review Panel gave provincial approval and recommended that the federal government approve three of the four components of the project (NRCB, CEAA 1998):

- The construction of the Twin Valley Reservoir.
- The construction of diversion works on Mosquito Creek and the canal leading to Clear Lake.
- The expansion of the diversion works on the Highwood River and the canal to the Little Bow River.

The Panel deferred a decision on the fourth component, the diversion plan for the Highwood River during the low flow season of late July and August, pending the receipt and review of additional information on the Highwood Diversion Plan. The Panel also concluded that, "….. additional storage for the Highwood basin is required to provide for a healthy river ecology, sustained fisheries and to deal with projected deficits for irrigators on the Highwood and Little Bow Rivers." The NRCB directed Alberta Infrastructure and Transportation to conduct further work into alternative storage sites.

In June, 2000, the Panel agreed that the review of storage options would be best conducted within the broader context of the Highwood Water Management Plan. The Panel also requested that the HWMP investigate the full range of options for addressing existing and future water demands in the basin.

Phase 1 of the Highwood Water Management Plan focuses on tasks related to the information needs of the Joint Review Panel, including the development of a diversion plan for the Highwood River and consideration of the full range of storage and non-storage options for resolving water management issues. In the course of this work, it became evident that the three components of the project that were approved for implementation would be constructed and operational before a Highwood Diversion Plan could be finalized. To facilitate operation of the project prior to the development of a Highwood Diversion Plan, attention was focused on the development of an Interim Diversion Plan (IDP) as Phase 1 of the Highwood Water Management Plan.

1.2 Planning Area

The study area includes the entire Highwood River basin, including the Sheep River (its major tributary), and the Little Bow River basin upstream of Travers Reservoir (Figure 1). The Sheep River Sub-basin was considered at the lesser level of detail than the remainder of the Highwood River Basin because of its downstream location and its minimal influence on the Highwood Diversion Plan. The Little Bow basin is comprised of three sub-basins that are distinctive due to their manmade sources of water supply.

1. The Upper Little Bow Sub-basin is defined by the Little Bow drainage area upstream of the Twin Valley Reservoir. The mainstem reach within this area is supplied by natural flows plus diversions from the Highwood River through the Little Bow diversion works.
2. The Lower Little Bow Sub-basin is defined by the drainage area that contributes flow to the mainstem from the Twin Valley Reservoir to Travers Reservoir, including the local drainage area to the Twin Valley Reservoir. The mainstem reach within this area is supplied by natural flow plus releases from the Twin Valley Reservoir.

3. The Mosquito Creek Sub-basin is defined by the drainage area of Mosquito Creek upstream of the Twin Valley Reservoir. The mainstem reach downstream of Women's Coulee is supplied by natural flow plus diversions from the Highwood River through the Women's Coulee diversion works. For assessment of irrigation performance, Mosquito Creek is further sub-divided as Upper Mosquito Creek, which includes Women's Coulee and Mosquito Creek upstream of Nanton, and Lower Mosquito Creek, which refers to the reach of the creek between Nanton and Twin Valley Reservoir.

When the term Mosquito Creek Sub-basin is used, it refers to Upper and Lower Mosquito Creek Sub-basins. When the term Little Bow River Basin is used, it refers to Upper and Little Bow River Sub-basins and Mosquito Creek Sub-basin. When the term study area is used, it refers to the Highwood River and the Little Bow River Basins.

1.3 Approach

The approach to developing recommendations for the Highwood Diversion Plan can be characterized as collaborative, balanced and adaptive.

Collaborative
PAC subcommittees, government staff (e.g. Alberta Environment, Alberta Agriculture, Food and Rural Development, Alberta Transportation, Alberta Sustainable Resource Development) and consultants (e.g. Hart Water Management, AMEC, Stewart Rood) worked closely during data collection, scenario development and evaluation. Community water user groups were consulted for input (e.g. irrigators, livestock operators, industry and municipalities). Decisions were made through consensus and the Phase 1 recommendations were explored in the broader community through open house forums.

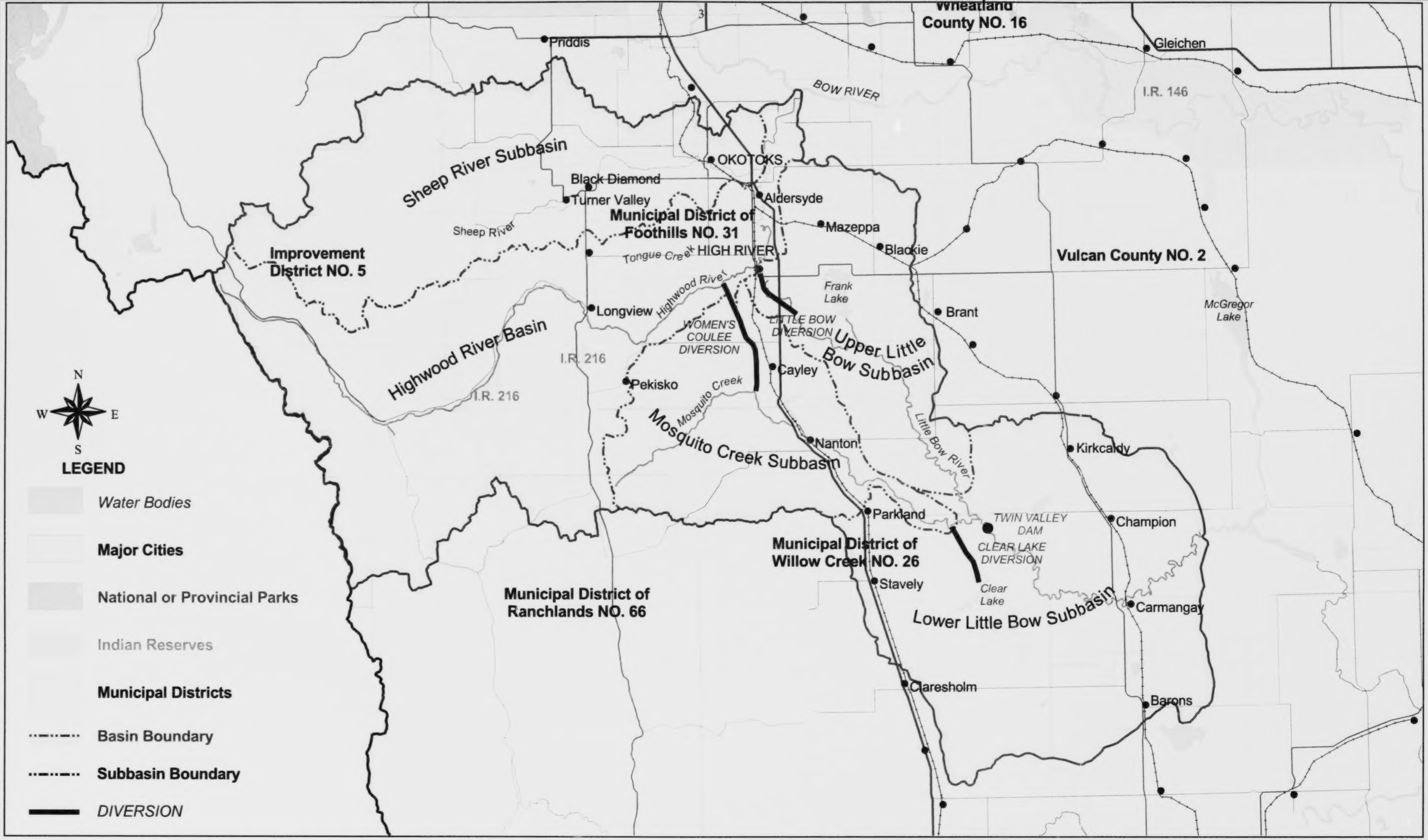
Balanced
Over 60 water balance scenarios were developed and evaluated in an effort to find the best balance between water consumption (e.g. municipal, irrigation, industry, stockwater) and environmental protection (e.g. fish habitat, water quality, riparian habitat) while staying within legal priorities.

Adaptive
Water balance modelling showed there was little flexibility in the operations of Highwood Diversion Plan (HDP) and that flow changes contemplated are very small. The impacts of the flow changes in the revised diversion plan will not be known and its performance under real rather than modelled operations is still to be tested hence the operations of the HDP will need to be performance monitored, assessed and revised as new information comes available. A process of adaptive management will be established with PAC input.

1.4 About This Report

This report summarizes the work of the Highwood Water Management Plan Public Advisory Committee, Alberta Environment, Alberta Infrastructure and Transportation and consultants in developing a recommendation for a Highwood Diversion Plan. It has been prepared to serve three purposes:

- To promote a public understanding of the state of water supply and demand in the Highwood and Little Bow River Basins, and the interdependencies between the two basins.
- To document data and assumptions, describe analytical tools, and provide rationale used to arrive at a recommended Highwood Diversion Plan for future reference.
- To provide a basis for discussion at future public meetings or public hearings on water management in the Highwood and Little Bow River Basins.


Wheatland County NO. 16
Priddis
3
Gleichen
BOW RIVER
I.R. 146
Sheep River Subbasin
OKOTOKS
Black Diamond
Turner Valley
Aldersyde
Municipal District of Foothills NO. 31
Mazeppa
Sheep River
Improvement District NO. 5
Tongue Creek
HIGH RIVER
Blackie
Vulcan County NO. 2
Frank Lake
Highwood River
Longview
WOMEN'S COULEE DIVERSION
LITTLE BOW DIVERSION
Brant
McGregor Lake
Upper Little Bow Subbasin
Highwood River Basin
I.R. 216
Cayley
Pekisko
Mosquito Creek
I.R. 216
Little Bow River
Mosquito Creek Subbasin
Nanton
Kirkcaldy
N
W
E
S
LEGEND
Water Bodies
Major Cities
National or Provincial Parks
Indian Reserves
Municipal Districts
Basin Boundary
Subbasin Boundary
DIVERSION
Parkland
TWIN VALLEY DAM
Champion
CLEAR LAKE DIVERSION
Municipal District of Willow Creek NO. 26
Stavely
Clear Lake
Municipal District of Ranchlands NO. 66
Carmangay
Lower Little Bow Subbasin
Claresholm
Barons

10 0 10 20 30

Kilometers

Scale 1:50,000

Source: Adapted from Figure 2.1
Non-Storage Options Assessment
AMEC Nov 2001

CLIENT: Highwood Management Plan - Public Advisory Committee	DATE: March, 2006	ANALYST: CMP	Figure 1
PROJECT: Highwood River Basin Water Management Phase 1: Highwood Diversion Plan	JOB No: CWP06009		
TITLE: Key Plan of the Study Area	COREL FILE: Figure_1.cdr		

Chapter 2.0 of this report provides a summary of the public consultation process that was an integral part of the Phase I study. **Chapter 3.0** summarizes the objectives, scope and findings of component studies that provided the technical basis for the study. Additional information on these component studies is available in a compendium and various reports that are referenced in Chapter 3.0. **Chapters 4.0** discusses scenario development for simulation modeling, evaluation parameters and criteria, and the findings of various scenario runs, leading to the best compromise scenario that is judged to balance environmental protection and consumptive uses in the study area**. Chapter 5.0** describes the characteristics and performance of the scenario that is recommended to form the basis for developing the Highwood Diversion Plan. **Chapter 6.0** describes specific issues that were addressed by the study team during the course of investigations. Draft recommendations of the Public Advisory Committee are listed and rationale provided in **Chapter 7.0**. Public input on the draft recommendations is summarized in **Chapter 8.0**. The final recommendations of the Public Advisory Committee are provided in **Chapter 9.0** and the Executive Summary. A listing of the **references** used in the preparation of this report follows Chapter 9.0.

Appendix A describes the relationships between this planning program and other ongoing planning activities, which is a requirement specified in the framework for water management planning (Alberta Environment, Undated).

Appendix B provides supporting information to Chapter 2.0: Public Involvement in the form of seven Attachments. **Appendix C** provides an example of water ordering procedures used by irrigation districts in southern Alberta. **Appendix D** provides glossary of terms commonly used in the report. **Appendix E** is a table of unit conversion factors (on the last page of the report for easy reference). This report primarily uses the metric system of measurement. Imperial units are sometimes used where it is felt that there is a significant historical familiarity with the value. Conversion factors for the units most frequently used in this report are noted in the sidebar.

- **Length or depth**
  1.0 kilometre (km) = 0.621 miles
  1.0 millimetre (mm) = 0.0394 inches
- **Area**
  1.0 hectare (ha) = 2.47 acres
- **Volume**
  1.0 cubic decameter (dam^3)
  = 0.81 acre feet
- **Rate of flow**
  1.0 cubic metre per second (m^3/s)
  = 35.315 cubic feet per second (cfs)

Abbreviations and acronyms used in this report are shown in brackets following first use of the full name or term. The full name may be repeated from time to time. Where names of government agencies or programs have changed during the life of this project, the current name is used. For instance, design and construction of the Little Bow Project has been the responsibility of Alberta Public Works, Supply and Services, Alberta Infrastructure, Alberta Transportation, and now Alberta Infrastructure and Transportation. The latter name is used in this report. It could mean any one of the predecessor agencies.

2.0 Public Involvement

This chapter provides a summary of the design and implementation of a public involvement program for Phase 1 of the Highwood Water Management Plan (HWMP). Phase 1 includes development of the Highwood Diversion Plan (HDP).

2.1 Establishment of the Public Advisory Committee

Diversions from the Highwood River to the Little Bow River Basin have long been a source of controversy, conflicting public views and contentious water management decision-making. Forging of a community-government partnership to address and resolve the water management issues in the Highwood-Little Bow Basins proved to be difficult.

History of Contentious Water Management Decisions. The need to resolve this conflict over water management solutions in the basin and provide for sustainable water management planning has been recognised since the 1980's and was recommended as early as 1991 by the Highwood IFN Technical Subcommittee, who made the approval of the contentious preliminary IFN contingent on the completion of a Highwood Water Management Plan. Alberta Government did not act on this recommendation and persisted with its 1996 application to the NRCB for approval of the Little Bow Project and a revised Highwood Diversion Plan that included the contentious IFN implications for future water management in the basin. A year later this application would result in a nineteen-day NRCB/CEAA Joint Review Panel Public Hearing that led to this Panel's May 1998 Decision Report that concluded that water management practices on the Highwood River were unsustainable and of potentially serious concern.

The Panel felt that at least part of the water management problems identified through the Hearing could be addressed through the development of the Little Bow project; hence it approved the building of the three infrastructure components of this project. The Panel remained concerned about the negative implications and inadequacies of the water management components (Highwood Diversion Plan with Expanded Women's Coulee Storage). Decision on these components was deferred pending additional information on storage options in the Highwood Basin and on the proposed changes to the water diversion rates from the Highwood River. The Panel requested delivery of this additional information by May 1999, along with a plan for the set-up of a public process to complete a Highwood Water Management Plan. The design of this plan was to provide for:

- an independent mediated/facilitated consultative public process;
- a process to identify all stakeholders and their respective community representation;
- detailed timelines for the completion of the HWMP planning process within a period of two years; and,
- cost estimates for the consulting services and studies related to design and implementation of the HWMP.

Problematic Government Public Consultation. In response to the Panel's orders and timeline constraints the government undertook to address these tasks through two parallel run projects involving the affected community through a non-facilitated government driven process. Alberta Infrastructure (now Alberta Infrastructure and Transportation) would lead the project for addressing the outstanding Little Bow Project component tasks and Alberta Environment would initiate the project work for the Highwood Water Management Plan. The public consultation for these projects started in late 1998 and involved mainly disenchanted community intervener groups from the Little Bow Project Hearing. There were also new concerned community groups brought into the process because of the expanded Highwood storage site investigations requested by the Panel. By March 2000 this public consultation process was stalled by time delaying procedural problems caused by community groups frustrated or confused by an uncoordinated process trying to address two related water management projects. Many felt the diversion plan and storage studies should be done within the framework of the water management plan, and others felt that the water management plan should be done first. For the newly involved storage site stakeholders the process offered little more than information over-load and no time to make informed decisions. In general community groups lost confidence in the government's approach to provide reliable information and to resolve the conflict resulting from the dissenting views held by the affected community on water management priorities and solutions for the Highwood River. This general breakdown in the consultation process led to two important public Joint Review Panel meetings held on April 19, 2000 and December 1, 2001 to respond to government and community stakeholder concerns about the public process.

Mediation to Set-up Public Advisory Committee. The results of the April 2000 meeting ultimately led to Environment and Infrastructure deciding to revise the government approach to the public consultative process by agreeing to a mediated/facilitated process to set-up an independent Public Advisory Committee that would drive the consultative process using guidelines it helped develop. Environment further revised its Terms of Reference (TOR) for the HWMP to include the investigation of the diversion plan and storage options under the umbrella of the water management studies of the Highwood Water Management Plan (Appendix B: Attachment 1). The stakeholders supported these changes, pending opportunity to amend the TOR, and by March 2001 the PAC membership was identified and set-up through a mediated public outreach process (Appendix B: Attachment 2). By September 2001 this PAC would develop and ratify, under mediation, its operation guidelines (Appendix B: Attachment 3) and decision-making procedures (Appendix B: Attachment 3-Figure 1). In December 2001 project plans were agreed on and it was realised that the process timelines were being seriously constrained by deadlines set by the Panel for the completion of the Little Bow Project reservoir that would be ready for a revised operations diversion plan in March 2002. The HWMP-PAC presented evidence that showed need for more time to conduct reliable technical investigations and to educate stakeholders. Alberta Infrastructure and Transportation agreed with this PAC concern and proposed a temporary solution to use the Interim Diversion Plan proposed in the Little Bow Project Application for the operation of the Little Bow Project until an acceptable Highwood Diversion Plan was developed. Alberta Infrastructure and Transportation stated this plan would likely need to be implemented if a revised Highwood Diversion Plan supported by additional Highwood storage was recommended because time would be required to put the new storage in place. PAC supported this temporary measure and by the beginning of 2002 the PAC process was finally able to move forward as a functional community-government operated partnership.

2.2 Public Advisory Committee Membership

The PAC membership composition was established and ratified through a mediated public outreach process that was supported by Alberta Environment and Alberta Infrastructure and Transportation. The membership was considered to be a balanced and fair representation of diverse interests and still be of a size to be manageable and efficient. Given that the purpose of the PAC was to advise on water management planning and the potential for more water storage, the PAC membership represented storage site affected groups, interested local water consumer and fishery groups, and members from industry and municipalities lying within the Highwood River and Little Bow-Mosquito Creek basins. The initial community representation on the Phase 1 PAC is documented in Appendix B: Attachment 3-Table 1. The membership composition changed throughout the process with one member (First Nations) limiting its participation to the initial 2001 introductory meetings, and four groups (Industry, Lower Highwood Water Users and Tongue Creek) becoming inactive members in 2004. These groups continued to receive PAC activity updates and some of the inactive members occasionally participated in meetings but were not part of the voting quorum after 2004. A new member, Town of Nanton, was added shortly after the formation of PAC in September 2001. Nanton was designated one member and one alternate. The PAC membership and current member group status is shown in Appendix B: Attachment 4. With the exception of the First Nations the now non-participating groups supported the 2004 Draft Recommendations (Appendix C) at the February PAC Workshop and the September Open House

Sessions (Appendix B: Attachment 8). These draft recommendations were refined and approved for submission in 2006.

2.3 Operations of the Public Advisory Committee

The PAC used an elected Management Committee (MC) and Chairman to drive process operations. The Chairman worked closely with the MC and a government planner to co-ordinate PAC activities. The Chairman had no voting rights and represented the overall PAC. The MC was required to see that business was carried out as requested by the PAC and to meet periodically with PAC at key education and decision-making junctures in the process. The PAC made extensive use of subcommittees to handle specific tasks. The Management Committee worked closely with the subcommittees, government and special interest groups to meet the needs of PAC. The membership of these subcommittees included interested PAC members, government representatives and independent experts. The PAC set-up several subcommittees to run and focus tasks on investigations in five major areas of investigation:

- data base upgrading and scenario modelling,
- storage options assessment,
- non-storage options preliminary investigation,
- Highwood IFN review, and
- Open House public meetings.

Continuity and accountability in this part of the process was assured through the participation of the Chairman and often one or more of the Management Committee members in the task Subcommittee activities, the results of which were reported back to PAC.

In its pursuit of recommendations for the Highwood Diversion Plan, the PAC was required to be mindful of water regulations, government policies and the Panel's objectives for a revised HDP. Within these constraints the PAC would be required do the following.

- Assess and place priorities on how much water was needed for community use and still leave sufficient water to maintain the aquatic health of the streams delivering the water.
- Assess storage options and examine non-storage options to determine their potential to improve on the efficiency of water use and/or to augment supply.
- Make water management recommendations based on community-defined priorities determined through collaborative consultation with local interested community water user groups and water resource experts from government and the private sector.
- Make recommendations through a decision-making process that promoted consensual agreement among the PAC membership and to acknowledge dissenting views where consensus could not be reached.
- Document its recommendations and take them back to the broader local community in Open House reviews, the results of which would be documented and considered in PAC's final analysis of the recommendations for a new Highwood Diversion Plan.

Once satisfied that this community consultation was adequately addressed, PAC was required to document its recommendations for a new Highwood Diversion Plan in a report and submit it to Alberta Environment. Depending on the nature of the Alberta Environment response, PAC might find need to submit additional comment to the Joint Review Panel.

2.4 Government's Role

Under the HWMP-PAC operation protocols, government would not hold designated seats on the PAC, however, as part of the partnership collaboration government representatives would be invited to sit at the

PAC discussion table but could not participate in any final decision-making procedures. As part of the government role in the PAC process Alberta Environment and Alberta Infrastructure and Transportation would assure government in-house support for technical, planning, and secretarial and policy advice services, as well as, provide a budget to support private consultant services and PAC administration hard costs. Government would seek PAC's input in designing a budget and would administrate and track the use of the budget. Once Environment received and reviewed PAC's Phase 1 Recommendations Report, it would advise PAC of its assessment of the recommendations. Then it would submit a revised Highwood Diversion Plan to the Joint Review Panel along with the PAC report and other supporting documentation in accordance with the government defined approval process for the HDP (Appendix B: Attachment 5).

2.5 Assessment of the Process

The PAC/government partnership was effective and productive in that it was able to overcome the obstacles of a long history of public consultations fraught with dissension. Credit goes to the volunteers and government participants who turned the process into a strong team effort that led to innovative solutions that PAC could unanimously agree on and the broader community could support (Appendix B: Attachment 6). The partnership was able to meet the Phase 1 objectives for the development of an HDP and provide tools and guidelines for future Phase 2 planning. These include the following.

- A process for a community-government partnership consultative process utilising consensus decision-making,
- Revised data base to build on for future local water management scenario modelling,
- Methods for developing and assessing the performance of water balance scenarios in terms of water quantity and quality, riparian and channel health, fishery and consumptive needs for future water management planning.
- Method for drought triggered storage water operations planning in the basin,
- Guidelines for socio-economic and environmental assessment of storage expansion in the basin, and
- Performance monitoring and tracking guidelines for adaptive water management in the basin.

The success achieved came with a cost. The Phase 1 PAC process involved over 130 meetings and cost over 1.5 million dollars for studies and operations during the period March 2001 to March 2006 (Appendix B: Attachments 7 and 8). This cost does not include the dollar value of in-kind services donated by the PAC members and government staff. The costs serve as indicator of the expenditures required for water management planning when trying to achieve sustainable solutions to complicated water issues. The government resource contribution to the HWMP Phase 1 process was substantial and important to the success of this process.

The process was sometimes plagued by timeline delay problems and PAC came under criticism from its community and government for taking too much time to complete Phase 1. The reasons for these perceived timeline delays are discussed. It should be noted that factors controlling the timeline delays were largely beyond the control of PAC and were often justified to resolve PAC or government concerns about process operations or outcomes. Factors included:

- PAC inherited complicated water issues that grew out of a long history of government run project processes that were proposed without the benefits of a sustainable water management plan, hence it took nearly three years for the public consultative process to become functional before the real work on Phase 1 could get started.

- PAC inherited outdated and/or incomplete water databases and inadequate analytical tools. Water supply and demand data had to be upgraded to be reflective of the local watershed. Scenario modelling tools had to be adapted to be sensitive to flow conditions and water use on the Highwood-Little Bow system and scenario performance assessment tools and standards had to be developed to screen scenarios. Furthermore, this assessment process would also have to consider the new (2001) Highwood IFN criteria that came with its own set of issues.

- Deadline extensions had to be renegotiated to enable education of the PAC through reliable water management studies that were reflective of the basin and its community.

- Unexpected concerns raised by DFO that required further scenario modelling and analysis.

- Planning and co-ordination had to work around the schedules of the volunteers and government participants. These stakeholders came from urban and rural communities where daily livelihood activities and schedules, often conflicted with the needs of the PAC schedule. Rural stakeholders were dominant and their schedules were often influenced by the vagaries of Alberta weather that sometimes led to timetable changes and delays. Furthermore, availability of in-house government services was sometimes interrupted or delayed due to internal staff changes and scheduling.

2.6 Concerns for Future Process Operations

Based on the experiences gained from the Phase 1 process there are two areas of concern for the future operations of the PAC process.

- **Long term data and information management** is the first of these concerns. Early in the Phase 1 PAC process subcommittees found it difficult to locate or access some databases or locate referenced documents, including policy documents. In some cases much needed data had not even been collated for a number of years. Given this experience the Management Committee recognised the need to create an accessible storage file for key information and data base management for the HWMP PAC process. Early in the PAC process it was realised that a volunteer group such as PAC did not have the capacity to set up and maintain an accessible storage file for proper data base management that might be required for future water management planning or for quality assurance. With the help of a government planner a good attempt was made to set-up such a Highwood Water Management Plan information storage file for Phase 1 in Environment. Unfortunately it became evident that continuity in maintaining such a file can be disrupted and information lost due to staff changes and reorganisation if personnel and protocols are not in place to assure this institutional memory is maintained for future adaptive water/watershed management planning. Currently this file remains incomplete some information documents and data bases being stored in various government departments or with consultants or PAC and this remains a concern for long term planning.

- **Partnership instability** is the other area of concern for future water management planning in the basin. The HWMP-PAC Phase 1 membership formed in response to various concerns about water management projects and their implications for affected community groups. Under such circumstances it has been observed in Phase 1 PAC experience is that participating members usually have their own agenda to be addressed through the process and as such they may decide, that once their agenda is met, to withdraw from the membership or choose to become non-participating members. The Management Committee remains concerned about the impact of increasing membership attrition on PAC's capability to move forward with Phase 2 under the regional Bow-Oldman Watershed Planning process. Assuring continuity for a seamless transition from Phase 1 to Phase 2 and meeting the Phase 1 PAC recommendations to track performance monitoring of the HDP for adaptive management could be difficult once the Phase 1 PAC partnership is dissolved. If government intends to change its role or involvement in this partnership then there is a need for discussion and appropriate planning to address the implications of this change before a Phase 2 can proceed.

3.0 Summary of Components

This chapter provides a summary of the component studies conducted primarily between 2000 and 2005 to address various issues or to provide or update databases. More detailed information on most of the components is available in Volume 2: Compendium of Background Information. A list of components in the compendium is located in the table of contents of this report.

3.1 Water Supply

The characteristics and impacts of droughts on large water management systems, such as exist in the South Saskatchewan River Basin, are often addressed through simulation modelling using a historical period of stream flow and weather conditions. The approach is based on the premise that the performance of management scenario (a particular existing or future physical system and mode of operation) over a lengthy period of recorded conditions, that includes representative flood and drought periods, provides insight into how well the system will perform in the future. The procedure requires a representative streamflow database at key points throughout the study area. The number and location of data points is dependent on the resolution required in model output (density of flow, reservoir levels, diversions, and demand data points in various parts of the study area). The model configured to provide output data where it is needed to evaluate performance of the system, draw conclusions and make recommendations.

3.1.1 Natural Flow Database

Simulation modelling refers to the mathematical representation of the performance of a physical system over a sequence of time steps. The physical system is the configuration of streams, diversions, canals and reservoirs represented in the model as a network of nodes and links. The nodes are locations in the physical system where there are reservoirs, stream or canal junctions, diversions or major withdrawals or inflows. Links are streams and canals. Key input data for simulation modelling are natural flows at key locations (model nodes) throughout the study area.

Why are "natural flow" data needed? Recorded data for most hydrometric stations in the Highwood/Little Bow/Mosquito Creek system cannot be used directly in the model since they reflect a water use pattern that has been changing continuously throughout the recorded period. To be useful for simulation modelling, recorded flows have been adjusted to provide a more consistent database by removing the influence of some of the larger human interventions in the hydrologic regime. Simply put, the method involves adding recorded upstream diversions (uses or regulations) to recorded flows at hydrometric stations to remove the effects of human interventions.

The natural flow database for the Highwood/Little Bow/Mosquito Creek system consists of weekly flows for the period 1928 to 1995. Development of the database involved estimating diversions and some water uses, filling in data gaps and extending records, and estimating flow at ungauged locations.

A description of procedures used for development of the natural flow database and its limitations are documented in the Fact Sheet, **Natural Flow Database and Model Configuration** (Hart 2004; Compendium). Key findings were as follows:

- Historical uses for "minor" projects, such as stockwater, domestic, municipal, and industrial uses, were not accounted for in the natural flow computations because of the difficulty of estimating these uses for the entire study period. As a result, computed natural flow is lower than actual natural flow near the end of the study period when these minor uses would be highest, but closer to actual natural flow near the beginning of the study period when minor uses would be low. From an analysis of this issue, it was concluded that the modeling error caused by not considering minor uses in the natural flow computations would be small, and on the conservative side. That is, the modelled available water would be slightly less than what is actually available. The computational effort required to estimate the minor uses for the entire study period is not warranted.

- Land use changes, such as forestry practices, cultivation, roads and urban development, would have some impact on flows. These impacts are largely unknown and have not been considered in the natural flow computations. Attempting to consider them may introduce more error in the database than accepting the data as is.

- There has been no attempt to consider natural spills from the Highwood River to the Little Bow River that have been cut off by flood control works, roads and railways. Such works would affect flows in high flow years, but have little or no effect in normal or low flow years that are of primary concern in the development of the Highwood Diversion Plan.

Channel losses due to priming dry channels, seepage, evaporation and transpiration are inherent in the recorded data. No adjustment to the natural flow database to account for channel losses is necessary.

- The methodologies used for filling data gaps, data extensions and estimating flows at ungauged sites are all standard procedures. The regression coefficients are high, indicating a good level of accuracy.

- The full scope of climate variability, and the impacts of climate change are two important water management considerations that are not addressed by simulation modelling using the recorded period of meteorological conditions. Results of modelling must be interpreted recognising the limitations of the input data on which the modelling is based. Where possible, flexibility should be designed into management decisions and the operation of the infrastructure to allow for mitigation of negative impacts and to take advantage of positive impacts of climate variability and climate change.

3.1.2 Model Configuration

The term "model configuration" refers to the manner in which the physical system is represented in the model. It is essential that all significant water management structures, inflow points and demands be accurately represented in the model. Beyond the representation of physical works and significant locations of supply and demand, the number of nodes in the model is dependant on the resolution required in the output data. Output data are required at all locations where performance of the system could affect the acceptability of a scenario run, and hence, recommendations of the planning program.

A detailed review of the model configuration was conducted by the modelling sub-committee to determine the number and location of output data points **(Natural Flow Database and Model Configuration** (Hart 2004; Compendium)). A few minor changes in model configuration were recommended and implemented. Natural flow sites were modified so that the total inflow at Carmangay did not enter the Twin Valley Reservoir. Frank Lake was added to the configuration so that increased spills to the Little Bow River as a result of the treated effluent inflows could be accounted for in the simulation runs. Several additional nodes were added to the model configuration to provide a better definition of flows along conveyance routes. Irrigation blocks were added to reflect four different priorities for irrigation demands.

3.2 Consumptive Water Demands

Estimates of current actual water demands in the study area are required to establish baseline conditions, or a Base Case against which future water management scenarios can be compared. The Base Case should reflect current conditions in the study area (pre-dam, pre-irrigation expansion, circa 2001 population and development). Future water use projections are required to determine the potential for additional development at various locations in the study area and to address trade-offs between future consumptive uses and environmental impacts.

Water licences and registrations define the location and purpose of water management projects in the study area, and provide an indication of the size of the projects. A review of water licences in the study area is a valuable first step in addressing water demands.

3.2.1 Water Licences

Licensed water allocation can be considered the upper limits of water use of licenced projects. The entire allocation may not be used every year, depending on many factors, such as weather conditions, water availability, and economic circumstances. Because of the continuing existence of riparian rights, not all water uses are reflected in the water licence database. Riparian landowners have a right to use, without an approval, licence or registration, up to 6.25 dam^3 per year for the purposes of livestock watering and crop spraying. Such use has no priority under the *Water Act*. Landowners using water for these purposes at the time the *Act* came into force had a right to "register" their uses, which would give them priorities dating back to when the use began. Riparian landowners have rights to use an additional 1.25 dam^3 for "household uses" without approvals, licences or registrations. These uses have higher priorities than licenced or registered uses. The livestock and household uses would be a small percentage of the licenced uses.

A listing of water licences in the Highwood, Sheep, Little Bow and Mosquito Creek Basins was provided by AENV in February 2002. Water licences were sorted by sub-basin, purpose, mainstem and tributaries. Surface water and groundwater licences were summarized separately. Registered wells were included in the listing, and are documented as stockwater projects. Registered surface water projects were not available. The total allocations for the registered surface water projects are expected to be small in relation to other surface water projects. (In any event, cattle populations have been used to estimate stockwater demand, rather than licences.)

Key Findings

Summaries of all licences with the foregoing breakdown are attached as Tables 1 to 9 in the Fact Sheet, ***Water Act*** **Licences** (Hart 2004; Compendium). The licences for the sub-basins are summarized in Table 1. Observations from review of the tables and individual licences are as follows:

Of the total number of licenced projects (surface water and groundwater) in the study area, 45 percent are in the Highwood River Basin (including Sheep River), and about 55 percent are in the Little Bow River Basin (including Mosquito Creek). Licensed allocations (volumes) are about equal in the two basins.

- There is a substantial difference in the distribution of licensed allocations for various purposes, reflecting the differences in population, climatic conditions and economic activities in the two basins, as shown below.

Table 1. Summary of February 2002 licences within sub-basins in the study area.

PURPOSE	Surface Water							Groundwater				
	No. Lic.	ALLOC	CONS	LOSS	RETURN	AREA	RATE	No. Lic.	ALLOC	CONS	LOSS	RETURN
		dam^3	dam^3	dam^3	dam^3	ha	m^3/s		dam^3	dam^3	Dam^3	dam^3
Highwood River Basin (excluding the Sheep River Sub-basin)												
Irrigation	34	4420.0	4219.0	201.0	0.0	2158.5	2.120	0	0.0	0.0	0.0	0.0
Agric/Stock	67	1075.0	639.0	436.0	0.0		0.083	179	359.9	359.9	0.0	0.0
Other Agric.	0	0.0	0.0	6.0	0.0			5	112.0	112.0	0.0	0.0
Recreation	2	2529.0	62.0	0.0	2467.0			0	0.0	0.0	0.0	0.0
Municipal	5	164.0	164.0	0.0	0.0		0.060	16	4847.6	1071.1	0.0	3776.4
Industrial	2	1653.0	1653.0	0.0	0.0		0.059	5	1446.0	253.7	59.0	1133.2
Water Mgmt.*	*2*	*27146*	*27146*	*0.0*	*0.0*		*1.700*	0	0.0	0.0	0.0	0.0
SUB-BASIN TOTAL*	110	9841.0	6737.0	643.0	2467.0	2158.5	2.322	205	6765.5	1796.7	59	4909.6
Sheep River Sub-basin												
Irrigation	15	1232.0	1226.0	6	0.0	558.2	1.139	0	0.0	0.0	0.0	0.0
Agric/Stock	90	890.0	401.0	490.0	0.0		0.012	225	232.8	232.8	0.0	0.0
Other Agric.	2	124.0	123.0	1.0	0.0	60.7	0.023	2	5.2	5.2	0.0	0.0
Recreation	4	353.0	318.0	35.0	0.0	98.0	0.093	9	36.9	36.9	0.0	0.0
Municipal	3	54.0	49.0	5.0	0.0	0.0	0.035	32	3112.9	1232.1	0.0	2480.8
Industrial	5	1591.0	1578.0	12.0	0.0	0.0	0.053	4	55.9	55.9	0.0	0.0
Water Mgmt.	0	0.0	0.0	0.0	0.0			4	69.1	69.1	0.0	0.0
SUB-BASIN TOTAL	119	4244.0	3695.0	549.0	0.0	716.9	1.355	276	3512.8	1632.0	0	2480.8
Upper Little Bow River Sub-basin												
Irrigation	20	2163.5	2163.5	0.0	0.0	691.3	0.934	0	0.0	0.0	0.0	0.0
Agric/Stock	7	39.43	16.0	23.42	0.0	0.0	0.003	174	313.7	313.7	0.0	0.0
Other Agric.	0	0.0	0.0	0.0	0.0	0.0	0	2	4.9	4.9	0.0	0.0
Recreation	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Municipal	2	313.0	308.0	5.0	0.0	0.0	0.116	8	95.0	38.7	0.0	56.2
Industrial	0	0.0	0.0	0.0	0.0	0.0	0	2	37.0	37.0	0.0	0.0
Water Mgmt.	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
SUB-BASIN TOTAL	29	2516.0	2487.5	28.4	0.0	691.3	1.053	186	450.6	394.3	0.0	56.2
Lower Little Bow River Sub-basin												
Irrigation	65	15397.3	15365.0	19.4	12.0	3716.7	3.638	1	61.7	61.7	0.0	0.0
Agric/Stock	22	128.0	28.0	100.0	0.0	0.0	0	179	212.4	212.4	0.0	0.0
Other Agric.	1	21.0	0.0	21.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Recreation	1	509.0	0.0	509.0	0.0	0.0	0	1	1.2	1.2	0.0	0.0
Municipal	6	363.0	227.0	136.0	0.0	0	0.076	11	228.8	154.8	0.0	74.0
Industrial	0	0.0	0.0	0.0	0.0	0.0	0.0	1	76.5	76.5	0.0	0.0
Water Mgmt.	0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0
SUB-BASIN TOTAL	95	16418.3	15620	785.4	12.0	3716.7	3.714	193	580.6	506.6	0.0	74.0
Mosquito Creek Sub-basin (including Women's Coulee)												
Irrigation	33	3199.0	3186.0	10.0	2.0	957.5	1.205	0	0.0	0.0	0.0	0.0
Agric/Stock	94	481.0	130.0	351.0	0.0	0.0	0	221	497.2	497.2	0.0	0.0
Other Agric.	0	0.0	0.0	0.0	0.0	0.0	0	2	9.7	9.7	0.0	0.0
Recreation	2	136.0	136.0	0.0	0.0	29.6	0.76	1	1.2	1.2	0.0	0.0
Municipal	2	703.1	122.1	21.0	560.0	0.0	0.108	8	42.0	27.2	0.0	14.8
Industrial	3	187.0	28.0	2.0	155.0	0.0	0.076	3	9.8	9.8	0.0	0.0
Water Mgmt.	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
SUB-BASIN TOTAL	134	4706.09	3602.12	383.97	717.0	987.1	2.149	235	559.9	545.1	0.0	14.8

Notes: * The Highwood River Sub-basin total excludes the 2 water management licences (diversions to Women's Coulee Reservoir) to provide a better comparison of development within each sub-basin.

1. ALLOC refers to allocation or withdrawal.
2. CONS indicates expected consumption.
3. LOSS indicates expected losses due to evaporation, infiltration, etc.
4. RETURN indicates expected return flow.
5. AREA refers to the size of irrigation projects.
6. RATE refers to maximum diversion rate.
7. Data in the table includes both mainstem and tributary licences.

Purpose	Highwood Basin (inc Sheep R.)	Little Bow Basin (inc Mosquito Cr)
Municipal	35%	7%
Irrigation	23%	82%
Industrial	19%	1%
Recreation	12%	3%
Stock and other agriculture	11%	7%

- Municipal licences include 13 wells licenced to High River and one to the M. D. of Foothills. All are within one section of land traversed by the Highwood River. For modeling purposes, withdrawals from these wells are assumed to be equivalent to a direct withdrawal from the Highwood River. Two industrial licences are for wells in the same section of land as the High River wells. For consistency, withdrawals from these wells are considered direct withdrawals from the Highwood River.

- Municipal allocations also include 24 groundwater licences for the Towns of Okotoks (12), Turner Valley (9), and Black Diamond (3). The wells are near the Sheep River. For modeling purposes, these withdrawals have been considered equivalent to direct withdrawals from the river.

- The two water management licences in the Highwood River Basin are for Women's Coulee Diversion. One licence for diversion of 0.71 m^3/s has a 1933 priority; the second licence for diversion of 0.99 m^3/s has a 1979 priority.

- A licence for the Little Bow Diversion was not included in the listing. The licencing situation for the Little Bow diversion has a complex history dating back to 1898 and involving the Territorial Government, the Little Bow Irrigation District and the Province. Upon demise of the Little Bow Irrigation District in 1950, the works were taken over by the Province. At that time, the Crown was not bound by the *Water Resources Act* (prior to 1971), and was deemed not to require a licence to operate works (Alberta Environment. 1997). The works are currently operated by Alberta Environment to serve the purposes for which the 1905 and 1922 applications were made (irrigation and domestic uses). In response to a 1997 application, an interim licence was granted under the *Water Resources Act* authorizing an enlargement of the diversion capacity from the pre-Little Bow project capacity of 2.8 m^3/s, to 8.5 m^3/s.

- The Town of Vulcan draws water from the Twin Valley Reservoir during normal operations. The location of their intake is such that when the reservoir drops below elevation 954.0 metres, the Town would be dependent upon river flows to meet their needs. For purposes of this work, their allocation is considered to be in the Upper Little Bow Sub-basin.

3.2.2 Current Water Demand

Actual water demand in the study area varies from year to year depending on several factors such as weather conditions, water availability, crop rotations and economic circumstances. Mean annual and monthly actual demands were estimated based upon the licence database, populations and on several purpose-specific factors and considerations. Demands were estimated by purpose and by sub-basin, and for mainstem and tributary sources. A detailed account of procedures used is given in the Fact Sheet, **Current Actual Water Demands** (Hart 2004; Compendium). Briefly, procedures were as follows:

- Irrigation -- Mean annual irrigation water demand for the various sub-basins in the study area was computed from weekly water demand estimates prepared by Alberta Agriculture, Food and Rural Development (AAFRD). The AAFRD estimates were based upon the crops grown in the sub-basin, irrigation efficiencies based on the types of irrigation equipment used in the area, and on-farm management typical of projects within irrigation districts in similar agro-climatic zones. AAFRD computes weekly irrigation demands for May to September each year for the 68-year study period, 1928 to 1995. The demands shown in Tables 1, 2 and 3 of the Fact Sheet, **Current Actual Water Demands** are based on the average annual demand for the entire period, with a typical monthly distribution.

- Livestock -- Estimates of livestock demands were based on domestic herd and feedlot cattle populations within the sub-basins of the study area, and average unit consumption rates. The procedures are discussed in a separate Fact Sheet, **Livestock Water Demands** (Hart 2004; Compendium).
- Other Agriculture -- Other agricultural demands, such as fish farming, and small market gardens, were assumed to be 80 percent of licensed values (AMEC 2001).
- Municipal and Rural Domestic – Municipal and rural domestic demands were estimated from population estimates and recorded or estimated per capita consumption, as outlined in the Fact Sheet, **Municipal and Rural Domestic Water Use** (Hart 2004; Compendium).
- Industrial – The largest industrial user in the study area is Cargill Foods. Their water demands were estimated from use records for 2000 and 2001. Demands for other industries were estimated based on discussions with licensees, or as a percentage of the licence allocation, varying from 65 to 85 percent.
- Recreation -- Golf course water demands were estimated based upon the irrigation area and a unit irrigation demand 30% higher than the agricultural irrigation demand, to reflect the optimum level of growth. Park irrigation was assumed to have a unit irrigation demand similar to agricultural irrigation.

A licence to divert Highwood River water to Frank Lake to supplement treated effluent inflows has not been used in recent years. An arbitrary water demand that may represent an average diversion over the years was assigned to the project.

Key Findings

The estimated mean annual demands and demands for the peak use month, July, are summarized in Table 2. More detail is available in the Fact Sheet, **Current Actual Water Demands** (Hart 2004; Compendium). Mainstem demands in all sub-basins are highest in the June, July, August period, primarily due to high irrigation demands. For purposes of developing the Highwood Diversion Plan, mainstem demands in July and August are most significant. During this period, irrigation use is typically high, Highwood River flows are typically low, and water temperatures are highest due to more frequent and prolonged high air temperatures. Observations from Table 2 are as follows.

- Irrigation is the predominant mainstem demand in all sub-basins. It is particularly high in the Upper and Lower Little Bow, and the Mosquito Creek sub-basins, being in excess of 93% of the total July demand in those sub-basins. Fully meeting the estimated mainstem July demands in the various sub-basins would deplete Highwood River flows by the following amounts:

Highwood River Sub-basin	0.678 m^3/s
Upper Little Bow Sub-basin	0.293 m^3/s
Mosquito Creek Sub-basin (inc. Women's Coulee)	0.398 m^3/s
Lower Little Bow Sub-basin (without L. Bow Res.)	2.329 m^3/s
Total	3.698 m^3/s

Table 2. Summary of estimated peak monthly (July) and annual mainstem water uses.

Purpose	Highwood River Mainstem[1]				Upper L. Bow R. Mainstem				Women's Co/Mosquito Mainstem[2]				Lower L. Bow Mainstem			
	July		Annual		July		Annual		July		Annual		July		Annual	
	dam^3	%	dam^3	%	dam^3	%	dam^3	%	dam^3	%	dam^3	%	dam^3	%	dam^3	%
Irrigation	1129.9	62.2%	3265.8	32.5%	739.8	94.2%	1974.7	84.0%	994.2	93.2%	2679.6	90.8%	6201.9	99.4%	15290.9	98.3%
Stock	27.8	1.5%	333.9	3.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Other Agric	0.0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Recreation	48.6	2.7%	470.5	4.7%	0	0.0%	0	0.0%	47.8	4.5%	128.8	4.4%	0	0.0%	0	0.0%
Municipal	307.3	16.9%	2899.8	28.8%	45.2	5.8%	375.8	16.0%	-0.3	0.0%	-4.5	-0.2%	34.8	0.6%	262	1.7%
Industrial	301.8	16.6%	3085.7	30.7%	0	0.0%	0	0.0%	24.5	2.3%	146.8	5.0%	0	0.0%	0	0.0%
Totals	1815.5	100.0%	10055.6	100.0%	785.0	100.0%	2350.5	100.0%	1066.2	100.0%	2950.7	100.0%	6236.7	100.0%	15552.9	100.0%
Totals (m^3/s)	0.678		0.319		0.293		0.075		0.398		0.094		2.329		0.493	

[1] Includes all Highwood River mainstem uses upstream of the confluence with the Sheep River.

[2] Does not include any Mosquito Creek uses upstream of the confluence with Women's Coulee.

- In the Highwood River Basin, the combined municipal and industrial demand is significant, comprising (potentially) almost 35% of the total July demand, primarily as a result of the Town of High River/Cargill Foods water supply system. (In this analysis it was assumed that all 12 production wells are either fed from the river or are intercepting groundwater flows that would normally enter the river. This assumption may have to be examined.)

3.3 Environmental Needs

An objective of the Public Advisory Committee was to meet all consumptive and environmental needs in the Highwood and Little Bow River Basins. However, if shortages are inevitable, trade-offs will be required to strike a balance between the needs of consumptive users and environmental values. Environmental indicators that were assessed include Highwood River instream flow needs, the flow requirements to maintain or re-establish riparian habitat conditions, and the minimum flow requirements to maintain acceptable water quality for certain water quality parameters in the Highwood and Upper Little Bow Rivers, and Mosquito Creek.

3.3.1 Highwood River Revised Instream Flow Needs

The Instream Flow Needs Technical Working Group[2] investigated several approaches for determining instream flow needs, recognizing that there is no one method that has gained acceptance or favor over others (Clipperton et al 2002). The "natural flow paradigm" was used as a guiding principle (sidebar).

The **"natural flow paradigm"** is becoming widely accepted among aquatic scientists and natural resource agencies around the world. Aquatic ecosystems have adapted to long-term variability in flow magnitude, frequency, duration, timing, and rate of change. Maintaining a similar pattern of flow variability is critical to the long-term sustainability and biodiversity of the aquatic and associated eco-systems.

The final recommendation of the Technical Working Group was based upon a time series analysis of scenarios that were defined as various percentage reductions from weekly natural flows. The Weighted Usable Areas (indices of the suitability of flows in a stream segment for a specific fish species and life stage) were computed for each scenario and all life stages for mountain whitefish and rainbow trout for the river reach between Aldersyde and the Sheep River confluence (Segment 4). Bull trout juvenile and adult life stages were also considered for the river reach between Women's Coulee and High River (Segment 2). Evaluation metrics were established as percentages reductions from natural Weighted Usable Areas that the working group judged would be acceptable and still provide a high level of protection, considering the magnitude of uncertainties inherent in the habitat computations. The three key metrics that were used for comparisons among scenarios and, their respective threshold reductions from natural habitat that were deemed acceptable were:

• Loss in average habitat.	Less than 10 percent reduction from natural.
• Maximum weekly loss in average habitat.	Less than 15 percent reduction from natural.
• Maximum one-week loss in habitat.	Less than 25 percent reduction from natural.

The evaluation metrics provide measures of long-term chronic impacts (average habitat), short-term chronic impacts (maximum weekly loss in average habitat) and acute impacts (maximum one-week habitat loss). The threshold criteria were applied to the life stage with the highest flow requirements, with the understanding that all other life stages with lower flow requirements would also be protected.

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[2] The Technical Working Group was formed by Alberta Infrastructure and Transportation to address Highwood instream flow needs. The group was not formed by or is part of the HWMP-PAC.

From evaluation of the scenarios using the three key metrics, the Working Group concluded that, subject to base flow constraints, the following instream flow requirements would provide a high level of protection of the aquatic ecosystem:

- Segment 2 – at least 80 percent of the natural flow.
- Segment 4 – at least 85 percent of the natural flow.

The Working Group recognized that low natural flow periods in the Highwood River create limiting habitat conditions. A reduction in flow during these periods could result in substantial negative impacts to the aquatic ecosystem. To provide additional protection during low natural flow periods, the Working Group established a threshold flow below which the instream flow requirement was 100 percent of the natural flow. This threshold value was referred to as the Ecosystem Base Flow. The Ecosystem Base Flow was established as the larger of:

- the flow corresponding to the 80 percent habitat exceedence value for the life stage with the highest flow requirement (mountain whitefish adult) for each week, or
- the weekly 95 percent flow exceedence discharge.

The Working Group decided to provide further protection for the late season weeks by extending the mid-August Ecosystem Base Flow, determined as above, through the remaining weeks of the open water season as a constant.

A channel maintenance flow assessment for the Highwood River near High River concluded that flows in the range of 75 to 150 m^3/s at least once every three years, for at least seven days each year, would be required to maintain the channel in its natural condition. It was subsequently determined that if the fish habitat derived instream flow regime was followed, the criteria would be met and the physical integrity of the Highwood River channel would be preserved.

3.3.2 Channel Processes and Riparian Habitat

The characteristics and qualities of riparian vegetation is highly dependent on the flow characteristics of the stream. The flow patterns along the Highwood River, Little Bow River and Mosquito Creek were examined for natural conditions, Base Case conditions (pre-Little Bow Project) and for a range of potential future conditions. The analyses concluded that the diversion scenarios would not likely have an appreciable effect on riparian vegetation along the Highwood River or Mosquito Creek. Little effect is anticipated on the Little Bow River downstream of Twin Valley Reservoir. The diversion scenarios show a potential for a significant improvement for riparian vegetation establishment along the Upper Little Bow River as a result of more favourable flow patterns.

Under natural conditions (pre-1900), the Little Bow River did not establish extensive riparian woodlands because of low and intermittent flows. Diversions from the Highwood River, which began in about 1905, led to establishment of some riparian willows and stands of balsam poplar, particularly along the upper reaches of the Little Bow River. With the enlarged diversion capacity, constructed in 2003, the Little Bow River will experience a period of instability and adjustment that will lead to substantial changes in the physical characteristics of the channel and associated vegetation. However, over the long term, it is expected that the higher flow regime will support expansion of the woodland vegetation.

A review of historical hydrology and the developmental history of the Little Bow River, past studies on environmental impacts of the increased diversion capacity, and studies and experiences on other similar streams was conducted to assist in predicting the impact of the new hydrologic regime on channel morphology and vegetation changes (Rood et al. 2002).

Key Findings

- Along the upper Little Bow River, there is substantial variation in the characteristics of the current channel and riparian vegetation due to grazing practices. Grazing impacts have led to wide, shallow channels and loss of riparian vegetation in some areas. These characteristics will persist under the new flow regime unless grazing practices change.

- The hydrologic regime will be substantially altered from the historical regime. Channel forming discharges will increase threefold, from about 1.0 m^3/s to about 3.0 m^3/s. It is expected that the channel width will increase by 50 to 75 percent. Course bed sediments will prevent the channel from significantly increasing in depth.

- Most existing vegetation along stream banks will be removed through river processes such as scouring, undercutting and slumping along outer banks, and flood-induced plant mortality along inner banks. Established trees and large willows will probably not be substantially affected, for the most part.

- The adjustment period for channel and vegetation changes is difficult to predict. The major initial changes may occur over a decade.

- Increased flows under the new hydrologic regime, and the supplemental soil moisture, should promote clonal suckering of willows, balsam poplar and aspens, and lead to expansion of the woodland groves.

- Recommendations to minimize environmental losses and promote environmental benefits are as follows.

    - Sufficient summer flows should be maintained to prevent drought-induced mortality of riparian plants. The minimum flow value suggested by the NRCB/CEAA Review Panel (NRCB, CEAA 1998) of 1.0 m^3/s may be a good starting point. However, monitoring should be carried out to assess conditions with the new flow regime and make adjustments to operations based on recorded data and field observations
    - When it becomes necessary to reduce diversions, ramped gradual reductions should be implemented. Abrupt changes should be avoided. Stage declines of two to four cm/d would permit new seedlings and saplings to grow roots to maintain contact with the receding soil moisture.
    - Livestock use of the streamside vegetation zone should be minimized, particularly while the stream is adapting to the new flow regime to encourage the recruitment of riparian vegetation.
    - Plantings of native shrubs along the Upper Little Bow River should be considered to kick-start riparian vegetation. Native plants properly located in the riparian zone should thrive under the new flow regime.
    - A monitoring program should be implemented to record and evaluate changes that occur along the channel and riparian zone, and to recommend refinements to operating procedures and land-use practices. The ongoing Cows and Fish Program (2001) in the Little Bow River Basin should be continued.

Negative impacts on riparian vegetation on managed streams can be prevented, at least in part, by adhering to operation procedures that recognize the essential requirements for streamside vegetation survival, growth and recruitment. In general, survival requires that seasonal minimum flows be established that would be experienced in not greater than 20 percent of the years. These minimum flows would be sufficient to temporarily sustain soil moisture and vegetation survival in low flow years. Chronic low flows would lead to progressive vegetation mortality. In 60 percent of the years higher early summer flows would be required to promote growth. Recruitment requires that in about 20 percent of years flows are sufficiently high to drive processes of sediment erosion, transport and deposition. These processes would leave saturated, barren streamside zones suitable for colonization of riparian plant communities.

3.3.3 Flows Required for the Maintenance of Water Quality

Relationships between recorded water quality and flow were developed and used in a comparative evaluation of water quality for various scenarios. Relationships were developed from studies conducted by Alberta Environment. The following critical parameters and locations were considered.

- Water temperature in the Highwood River downstream of High River (Cross 1989).
- Minimum daily dissolved oxygen in the Highwood River near Aldersyde (Sosiak 2001).
- Turbidity in the Highwood River near Aldersyde (Sosiak 2001).
- Dissolved oxygen in the Little Bow River at Highway No. 533 (Sosiak et al. 2002).
- Total suspended solids (TSS) in Mosquito Creek downstream of Nanton (Sosiak et al. 2002).

Subject to certain qualifications, the following conclusions were drawn from the results of the Alberta Environment studies. (The reader should refer to the cited reports for the qualifications.)

- Dissolved oxygen in the Highwood River would probably fall below Canadian Environmental Quality (CEQ) guideline (6.5 mg/L) only in midsummer when flows are below 8.0 m^3/s and at water temperatures above 24.0°C. Flows over 5.0 m^3/s would maintain dissolved oxygen above an acute dissolved oxygen criterion of 5.0 mg/l.
- Using water quality modelling, Cross (1989) determined that a flow of 8.0 m^3/s would prevent water temperature in the Highwood River from exceeding 24.0°C during hot weather. Monitoring during the period 1989 to 2000 generally supported this conclusion, except in one instance. Water temperature briefly peaked at 25.3°C on July 27, 1998 at a flow of 12.0 m^3/s following four days of maximum air temperatures ≥28°C. A water temperature of 24.0°C is the current guideline used for the curtailment of irrigation diversions on the Highwood/Little Bow system. Hence, on the Highwood/Little Bow system, water temperature will remain a more restrictive variable than dissolved oxygen for operation of diversion works.
- Dissolved oxygen levels in the Little Bow River at Highway No. 533 were predicted to be above 3.5 mg/L at flows of 1.11 m^3/s, and above 4.0 mg/L at flows of 1.8 m^3/s. A dissolved oxygen level of 3.5 mg/L is sufficient to protect adult cool water sport fish, such as walleye and northern pike (Taylor and Barton 1992). A dissolved oxygen level of 4.0 mg/L is sufficient to protect trout and walleye.
- Total suspended solids in Mosquito Creek downstream of Nanton during peak irrigation demand months were predicted to remain below Canadian Environmental Quality Guidelines at mean monthly flows ranging from 0.55 to 1.62 m3/s, depending on month. For instance, the critical flow would be 1.60 m^3/s in July and 1.26 m^3/s in August.

Based on the results of the analyses, the following water quality target flows were used to evaluate the performance of various water management scenarios in terms of meeting instream flow requirements for protection of water quality.

Flow Requirement	Location	Water Quality Parameter Protected
8.0 m^3/s, minimum	Highwood River at Aldersyde	Dissolved Oxygen, Temperature
1.11 m^3/s, minimum	Little Bow River at Hwy 533	Dissolved Oxygen
0.55 to 1.62 m^3/s, maximum (depending on month)	Mosquito Creek d/s Nanton	Total Suspended Solids (measured as non-filterable residue)

3.4 Model Development

Several computer simulation models were developed or adapted to the Highwood/Little Bow Basins to be used in analyzing and evaluating various scenarios for future management of water in the study area. Each of these models is briefly discussed in turn below.

3.4.1 Water Resources Management Model

The Water Resources Management Model (WRMM) was developed by AENV in the early 1980s, and has been continually updated and improved. It is the key planning tool used by AENV for determining the relationship between water supply and demand for water management scenarios or management options. Input data for the model include the following.

- Weekly lake evaporation and precipitation data, to account for reservoir losses.
- Natural flow data at key locations in the study area.
- Consumptive water demands for various purposes.
- Instream flow targets for key reaches.
- Conveyance channel, canal and reservoir outlet capacities, and reservoir storage characteristics and operating rules.
- The priority system for supplying water to the various users.

The model computes water deliveries to meet demands in accord with the priority system, stream and canal flows, and reservoir levels. Model output represents the conditions that probably would have occurred if the management scenario had been in place during the historical period of streamflow and climatic conditions simulated. Modeling in the Highwood/Little Bow Basins has been conducted using a weekly time step for the 68-year period 1928 to 1995.

The various management scenarios modelled and analyses of model results are discussed in detail in Chapter 4.0.

3.4.2 Irrigation Requirements Module

The Irrigation Requirements Module (IRM) is the on-farm irrigation demand component of AAFRD's Irrigation District Model (Irrigation Water Management Study Committee 2002). The IRM computes the amount of water to be applied using various on-farm irrigation equipment, to meet crop-specific requirements. The IRM operates on a daily time step. It considers soil moisture, weather conditions, efficiencies of various irrigation equipment, the moisture needs and timing of a variety of crop types, down times for set changes, maintenance and harvesting, and operator management proficiencies. Irrigation demands so-determined are often referred to as "farm gate demands". In the Highwood/Little Bow system, farm gate demands are the same as the diversion requirements at the water course, since there is no delivery system of main canals and laterals.

Irrigation demands generated for modeling in scenarios related to the Interim Diversion Plan are based on the assumption that irrigators would apply sufficient water to meet 80 percent of the optimum crop water requirement, and the irrigators would have a "standard" water management proficiency. Both these factors would be similar to that of irrigators growing similar crops within irrigation districts during the 1990s.

The IRM has been calibrated and validated to ensure that generated irrigation demands matched well with recorded values within irrigation districts, some of which have agro-climatic conditions and crop types similar to that of the Highwood/Little Bow study area. No direct calibration for the Highwood/Little Bow system was done due to a lack of recorded data in the study area.

Demands determined using the IRM are highly variable from year-to-year depending on weather variations. They vary from region to region in the study area, reflecting agro-climatic conditions and crop types. Table 3 summarizes the 10 percentile (cool, wet year), median (normal year) and 90 percentile (hot, dry year) demands for the sub-basins of the study area. The percentile values provide an indication of annual demand variations; the sub-basin demands show the regional variations. With exception of Mosquito Creek, demands increase from northwest to southeast in the study area, reflecting agro-climatic conditions. Mosquito Creek demands are higher than would be expected due to a high percentage of alfalfa in the crop mix. Alfalfa is one of the highest water demand crops grown in Alberta.

Table 3. Annual and regional variation in irrigation water demand.

	Farm Gate Demand in mm		
	10 percentile	Median	90 percentile
Highwood	103	187	285
Upper Little Bow	157	284	423
Mosquito Creek	198	344	462
Lower Little Bow	184	327	422
Clear Lake Expansion	182	338	439
Little Bow Expansion	169	311	414

3.4.3 Fish Habitat Model

Fish habitat modelling is based upon hydraulic and biological relationships that describe how habitat changes with flow. Establishing the relationships requires that the stream be characterized both hydraulically and biologically. The process involves selecting study sites to represent various stream segments and developing relationships based on recorded and theoretical data at the study sites.

The hydraulic component of the model computes water surface elevations, depths and velocities for the range of flows that could be experienced in the stream segment. Habitat suitability criteria are developed for specific species and life stages of fish based upon measurements of physical conditions in the stream (e.g. depth, velocity, substrate, cover) at locations where fish are actually observed. The habitat component of the model combines the hydraulic data with the biological criteria to compute indices, or Weighted Usable Areas (WUA), of available habitat in the stream for each specific life stage and fish species, and for the full range of flows expected in the stream segment.

The Instream Flow Needs Technical Working Group was established in September 1998 to review past instream flow needs studies for the Highwood River, and to provide a science-based instream flow determination for the river (Clipperton et al. 2002). Highwood River fisheries management objectives were updated for the study. The Working Group reviewed all available information and assumptions from previous studies. Improvements were made to the hydraulic modelling component. Habitat suitability relationships were modified based upon additional observations and expert opinions solicited at a workshop. The updated hydraulics and habitat criteria were used to develop new WUA relationships for use in the current study.

The relationship between flow and WUA for each species and life stage is the primary tool that is used to predict the relative impact of various water management scenarios on fish habitat. The ability to predict fish habitat indices for alternative streamflow patterns is essential for resource managers and the public who desire to understand the trade-offs between consumptive uses of water and the instream flow needs of fish.

3.4.4 Water Quality Model

The increased capacity of the Little Bow Diversion, construction of Twin Valley Dam and construction of the Clear Lake Diversion will alter the flow regimes of the Highwood River, Little Bow River, Women's Coulee and Mosquito Creek. The altered flow regimes will affect water quality in these streams. Also, there is concern about the suitability of water quality in the new Twin Valley Reservoir, Clear Lake, and the existing Women's Coulee Reservoir for the intended uses of these reservoirs.

A numerical computer model was developed to predict the effects of the altered flow regimes on water quality (Golder 2003). The US Army Corps of Engineers river and reservoir water quality model CE-QUAL-W2 was configured and calibrated for each of the relevant streams and reservoirs. The separate models were calibrated and then linked to form a single stream-reservoir modeling system. The interconnected model was then used to simulate water quality conditions for the 10-year period 1986 to 1995 for pre-project and post-project conditions. Results were presented in two ways; a) in terms of a time series of parameter values for the 10-year period, and b) the percent of time water quality was in compliance with guidelines for selected water quality parameters. Selected parameters included total dissolved solids, temperature, nutrients, aquatic plants and algae, and dissolved oxygen.

Further model development, calibration and verification are deemed to be required. Until additional work is carried out, model findings must be considered preliminary, particularly in terms of absolute values for specific parameters. Comparative values for pre-project and post-project conditions are less sensitive to absolute model accuracy, and are presented here to provide insights into impacts of the new flow regime and conditions.

For the purposes of this study, **water quality guidelines** were taken as presented in Little Bow Project/Highwood Diversion Plan Joint Review Panel Report (1998). Guidelines are intended to assist in evaluating the suitability of water quality for specific uses. They are not enforceable. Hence, compliance or non-compliance, as used in this comparative evaluation, has no legal connotations.

Preliminary model results indicate that the more salient impacts of post-project conditions, in terms of duration of compliance with guidelines, for each sub-basin were as follows.

- For the Highwood River, model results showed only minor differences in guideline compliance for all parameters modeled.
- For the Upper Little Bow River (once stabilized), results showed minor **increases** in guideline compliance for total dissolved solids and conductivity (critical use: irrigation).
- For the Lower Little Bow River, results showed significant **increases** in guideline compliance for fecal coliforms, turbidity (critical use: drinking water treatment), and conductivity (critical use: irrigation).
- For Mosquito Creek, results showed significant **increases** in guideline compliance for dissolved oxygen (critical impact: fish). (Turbidity almost always exceeded guidelines for both pre- and post-project conditions.)
- Based on model results for total phosphorus, Clear Lake is expected to be mesotrophic or better 15 percent of the time (moderate or less plant growth), and eutrophic or hypertrophic 85 percent of the time (abundant plant growth).
- Twin Valley Reservoir is predicted to be mesotrophic or better about 30 percent of the time, and eutrophic or hypertrophic 70 percent of the time.
- Women's Coulee Reservoir will continue to be clear, cold and fresh, and almost always oligotrophic (sparse plant growth).

3.4.5 Riparian Vegetation Model

A model has been developed to conduct comparative evaluations of the suitability of time series of weekly flows for vegetation survival, growth and recruitment along the upper Little Bow River. The relationship between instream flows and riparian vegetation is now reasonably-well understood (Rood 2002). Essential aspects of streamflow to establish and maintain healthy riparian plant communities are:

- Occasional scouring flows to prepare seed beds for recuitment.
- Sufficient channel water stage to recharge the riparian water table.
- Avoidance of abrupt reductions in water stage, which would lead to rapid decline of the riparian water table.

Riparian vegetation responds to water elevations rather than discharge. Stage-discharge relationships are required to convert conventional flow hydrographs to stage hydrographs. A weekly time step was considered to be an adequate time interval to relate to ecological responses. Daily stage recession rates (down ramping) can be interpolated from weekly time series.

The model compares patterns of river stages and ramping rates for historical conditions and various scenarios and relates these patterns to impacts on riparian plant communities. Outputs from the scenario modelling represent qualitative and semi-quantitative predictions about the recruitment, growth and survival of various riparian plant groups.

This model has been used to test the relative impacts of various water management scenarios on streamside vegetation. The evaluation process is based on comparative assessments, rather than absolute modelling. Because of the complexity of natural systems, the evaluations provide only relative insights to potential impacts and future conditions. It is therefore essential that monitoring be conducted to validate physical and biological responses along the streams. The monitoring program would provide a basis for validation of the performance assessments, and refinement to the operation of the system to minimize negative impacts and increase environmental benefits.

3.5 Additional Storage Development

The initial application for the Little Bow Project included an option to expand the Women's Coulee Reservoir from a storage capacity of 360 dam^3 to 6380 dam^3. The purpose of the additional storage was primarily to store water in the spring and release it during the summer to protect fish habitat by offsetting summer diversions to the Little Bow River. Although presented as an option, it was not supported in the application. Analysis had made it clear that the habitat benefits would be minimal.

During review of the application, the Joint Review Panel asked for an assessment of the largest possible reservoir that could be constructed in Women's Coulee without affecting Women's Buffalo Jump. It was determined that a reservoir with a capacity of 16,200 dam^3 could be built at that location. Using the rules within the Diversion Plan of the day, it was determined that such a reservoir could provide a reasonably reliable supply of water to offset deficits to consumptive demand and augment instream flows. The estimated cost of the project was $15.7 million, not including environmental mitigation.

In its decision report, the Panel indicated that additional water storage was needed in the Highwood River Basin to meet existing demands (NRCB, CEAA 1998). However, additional information was required to determine the best location for storage. Accordingly, NRCB Board Order 6, arising from the Joint Panel Decision Report, requested that a comparative site assessment be conducted to ensure that all reasonable alternatives were considered.

Alberta Infrastructure and Transportation (2001) considered several possible sites. Upon preliminary investigation, all but three sites were eliminated as infeasible or ineffective. The three sites that were considered in more detail were:

- Women's Coulee
- Tongue Creek, and
- Stimson Creek.

On the basis of more extensive and rigorous data gathering and analysis, Alberta Infrastructure and Transportation concluded that:

- The Women's Coulee site provides the best opportunity for the development of storage for the Highwood River Basin, having regard for cost, and social and environmental impacts.
- The Stimson Creek site is a poor option for storage development because of a limited and unreliable water supply.
- The Tongue Creek site provides similar storage and water management opportunities to the Women's Coulee site, but the capital and operations costs would be considerably higher, and the environmental and social impacts significantly greater.

The study determined that the cost of a 17,300 dam^3 Women's Coulee Reservoir would be in the order of $37.9 million including estimates for land acquisition and environmental mitigation. It determined that a reservoir of this size at that location with an inlet canal capacity of 3.4 m^3/sec could supply an average of 14,700 dam^3 per year. However, on average, there would still be about a 6000 dam^3 per year deficit to the consumptive needs and instream needs (instream needs were defined by Fish Rule Curve requirements as detailed in the Environmental Impact Assessment documents submitted with the application). Modelling at the time indicated that there would be adequate water supply in the spring to fill the storage virtually every year, but also identified demands that would empty it virtually every year.

The performance of the Women's Coulee Reservoir considering the recommended technical instream flow needs is discussed in more detail in a subsequent section of this report (Section 4.3.8).

3.6 Non-storage Options

A study was conducted by AMEC Earth and Environmental (AMEC 2001) to:

- determine the extent to which non-storage options might help resolve water management issues in the Highwood River, Little Bow River, and Mosquito Creek Basins,
- narrow the range of options to be considered in more detail by determining the cost-effectiveness (costs vs. benefits) of non-storage options, and
- to provide the information on non-storage options needed by the Public Advisory Committee (PAC) to develop recommendations on the diversion plan for the Highwood River.

More than 20 non-storage options were identified and their respective applications to resolving the imbalance in water supply and demand in the study area were discussed based upon a review of literature, and Alberta experiences. The study was of a preliminary nature. It provides a body of information for initiating efforts to develop and evaluate non-storage options.

3.6.1 Legal Instruments

The study concluded that, among several measures that would assist in resolving issues, voluntary water allocation transfers probably hold the most promise, particularly if the government became an active participant. Other *Water Act* measures that should be considered include deficit sharing, moratoria, and improved enforcement. Deficit sharing would help to reduce the impacts of water shortages. Retaining a moratorium in certain areas would help to prevent problems from escalating. Improved enforcement, particularly cancellation of inactive projects where there is no intention to resume operation, would improve planning and decision making in the study area. Water user acceptance of frequent deficits on existing projects and a government compensation program for benefits foregone may be less costly than storage development and warrant consideration in some areas.

3.6.2 Water Conservation Measures

The term "water conservation measures" usually refers to non-storage measures that reduce water use, or make water use more efficient.

There are a variety of ways to conserve water. Some methods are voluntary, some may be economically driven, and others may require regulatory action. The extent to which water users may adjust water consumption in response to a price increase is an important consideration in using pricing as an instrument for water conservation. For every use, the water use response is highly dependent upon the prevailing price regime. With low current prices, a small change in price would prompt a relatively large change in water use. Each additional price increase will result in a diminishing reduction in absolute quantities of water use.

Stockwater use estimates and losses for the Highwood River basin are high. Additional study is required to understand the locations, nature and status of licensed stockwater projects in the basin, and to determine the extent to which water conservation measures could be implemented.

3.6.3 Pipelines

Pumps and pipelines are efficient options to convey water from a source to the point of use. Pipelines help to conserve water by eliminating evaporation and seepage. Industries, municipalities and irrigation districts commonly use pipelines.

A re-circulation pipeline from the Twin Valley Reservoir to the headwaters of the Little Bow River and to Upper Mosquito Creek would provide an opportunity for water users upstream of the reservoir to take advantage of the storage during times when diversions from the Highwood River are constrained.

Conceptual level designs and cost estimates were prepared for three hypothetical pump and pipeline options (AMEC 2002). The intention of conducting this work is to obtain order-of-magnitude costs that help to put the options into perspective with other water supply opportunities. For each option, a range of demand rates were selected to provide cost estimates for a wide variety of possible projects. Capital cost estimates included right-of-way, pipe costs, installation, intake pump station and booster pump stations, crossings, mobilization/demobilization (3 percent), engineering (15 percent) and contingencies (25 percent). Annual cost estimates included energy requirements and annual maintenance estimated as 2.0 percent of capital costs.

Each of the three options and the study findings are described below.

- **Option 1: Tie-in to the City of Calgary municipal system to deliver treated water to municipalities in the Highwood and Little Bow River Basins.** The 71 km mainline pipe would extend from Calgary to Nanton and potentially supply supplemental municipal water to Dewinton, Okotoks, Aldersyde, High River, Cayley and Nanton. Laterals could be extended 23.5 km west to Black Diamond and Turner Valley, and 20.3 km east to Mazeppa and Blackie.

Option 1: Flow rate	Capital costs (millions of $2002)	Annual costs (millions of $2002)
0.20 m^3/s	$37.9	$1.3
0.50 m^3/s	$38.6	$2.0
1.10 m^3/s	$61.8	$4.3

Costs for this option do not include modifications to Calgary's infrastructure to accommodate this increase in supply.

- **Option 2: Pump untreated water 27.0 km from the Twin Valley Reservoir to the Little Bow and Women's Coulee Diversion Canals.** Untreated water would be available for High River and users along the Upper Little Bow River, Women's Coulee and Mosquito Creek.

Option 2: Flow rate	Capital costs (millions of $2002)	Annual costs (millions of $2002)
1.2 m^3/s	$52.0	$3.5
2.3 m^3/s	$72.2	$6.6
3.3 m^3/s	$92.0	$9.2

Costs do not include treatment to drinking water standards for municipal and domestic use. Annual costs are high primarily due to energy requirements for the high lift between Twin Valley Reservoir and High River.

- **Option 3: Construct an intake on the Bow River downstream of Calgary and pump untreated water to municipalities and to the Little Bow and Women's Coulee Diversion Canals.** The trunk line would serve Aldersyde, High River and the two diversion canals. Laterals could be constructed west to serve Okotoks, Black Diamond and Turner Valley, and east to serve Mazzeppa and Blackie.

Option 3: Flow rate	Capital costs (millions of $2002)	Annual costs (millions of $2002)
2.0 m^3/s	$93.9	$5.6
3.6 m^3/s	$107.6	$8.7
5.1 m^3/s	$124.6	$11.5

Costs do not include treatment to drinking water standards for municipal and domestic use. Like Option 2, annual costs are high primarily due to energy requirements for the high lift between the Bow River and High River.

Again, this cursory assessment should be considered only as a bracketing exercise, which establishes an initial basis for consideration of some pipeline options. More detailed planning and analyses are required to refine any one of these options, including input from landowners along the right-of-ways associated with the projects.

4.0 Scenario Development and Evaluations

4.1 Introduction

Simulation modelling assists in developing an understanding of the issues and provides a basis for a rational discussion of alternatives. Modelling mathematically determines the performance of a physical system over a sequence of time steps. The physical system is the configuration of streams, diversions, canals and reservoirs represented in the model as a network of nodes and links. The nodes are locations in the physical system where there are reservoirs, stream or canal junctions, diversions or major withdrawals or inflows. Links are streams and canals. Model configuration is discussed in Fact Sheet, **Natural Flow Database and Model Configuration** (Hart 2004; Compendium). Input data, assumptions and limitations are discussed in the Fact Sheet, **Computer Simulation Modelling** (Hart 2004; Compendium).

Water use priorities used in modeling are discussed in the document, **Scenario Construction and Priorities** (Czarnecki 2004; Compendium). Priorities are input to the model through a penalty point system. Deficits to high priority uses have high penalties; deficits to lower priority uses have lower penalties. The model contains an optimization procedure that minimizes the penalties throughout the entire system in each time step (week) to establish the perfect operational solution for that time step.

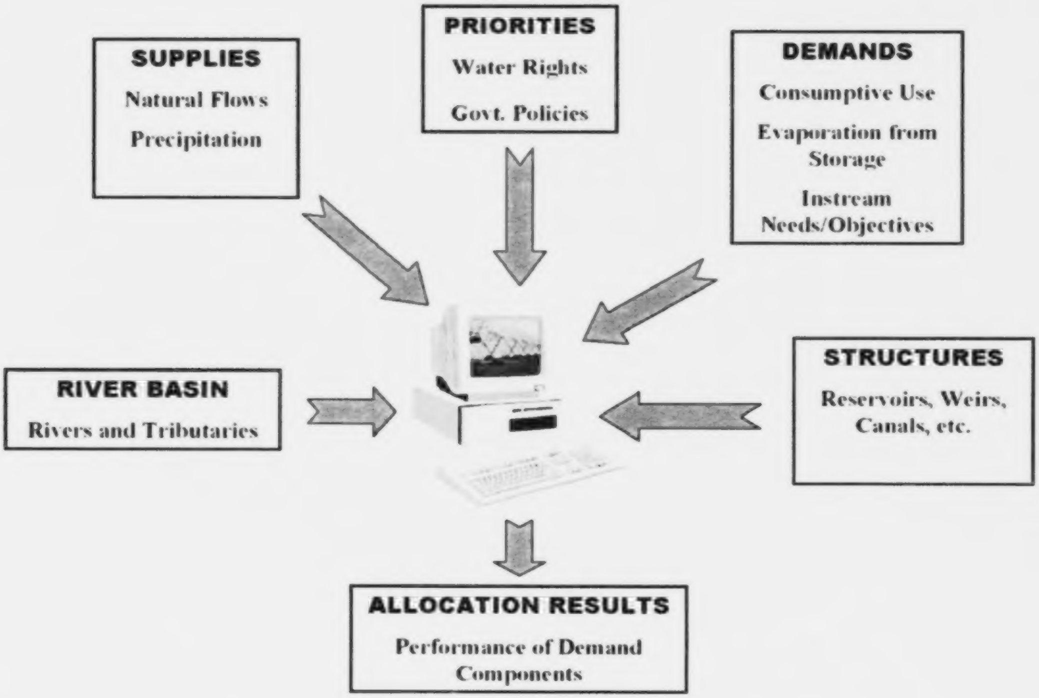

PRIORITIES
Water Rights
Govt. Policies
SUPPLIES
Natural Flows
Precipitation
DEMANDS
Consumptive Use
Evaporation from Storage
Instream Needs/Objectives
STRUCTURES
Reservoirs, Weirs, Canals, etc.
RIVER BASIN
Rivers and Tributaries
ALLOCATION RESULTS
Performance of Demand Components

Figure 2 **Input data required for simulation modeling.**

The model has perfect knowledge of supply and demand for each time step – in other words, perfect forecasting. In actual operation, the operators do not have perfect forecasting of supply or demand.

Attempting to match water deliveries to water demands in the face of uncertainty, operators naturally lean toward erring on the side of caution by delivering more water than might be required, to avoid pump cavitations, shut downs, lost revenues, and much aggravation for the operator and user alike. Model output for scenarios attempting to replicate existing conditions may be different than recorded system performance. The "operational gap" is common to all scenarios. Scenario performance is best evaluated in a comparative manner, comparing the performance of one scenario against that of another. The relative success or failure of model output should be comparable to the relative success or failure in real-time operations.

The model computes water deliveries to meet demands in accord with the priorities and constraints, such as canal capacities, within the system (Figure 2). It also computes the resulting stream and canal flows, and reservoir levels. Subject to assumptions and the limitations of database, model physical representations and the operational gap, the model output represents the conditions that probably would have existed if the management scenario had been in place during the historical period of streamflow and climatic conditions simulated.

The performance of the Highwood/Little Bow/Mosquito Creek system during low flow years and low flow months is a key factor in determining the impacts of a water management scenario. Performance is assessed by analyzing output data to determine how well objectives are met, or are not met. The severity, frequency and duration of failure to meet objectives are the most common measures of performance. Water management is multi-objective. Multiple performance measures are required. Simplified tables or graphics targeted to highlight the performance in meeting specific objectives assist in evaluating the performance of one management scenario against others. Balancing the performance of multiple objectives often requires trade-offs and value judgments. Simulation modeling to explore various "what if" scenarios helps to understand the trade-offs and work toward a consensus on the best-possible alternative.

Modeling in the Highwood/Little Bow Basins has been conducted using a weekly time step for the 68-year period 1928 to 1995.

A total of 60 scenarios were formulated, modelled and evaluated in the course of developing an Interim Diversion Plan. Fortunately, with modern computer equipment and output analyses programs, scenarios can be run and analyzed relatively quickly. All 60 scenarios will not be discussed in this document. An overview of the major thrusts in scenario development is provided. Key scenarios are discussed in more detail. An analysis of specific issues is discussed in Chapter 6.0.

4.2 Scenario Evaluation Parameters and Criteria

Performance parameters and criteria are summarized in Table 4. Note that, because of modeling assumptions and limitations, irrigation deficits are used as a surrogate indicator of deficits for any consumptive user (irrigation or non-irrigation), depending on licence priorities (sidebar). Percent of years with deficits greater than 100 mm was used as a comparative indicator. Irrigation experts and practitioners in Alberta have stated that farm gate deficits less than 100 mm are of little financial consequence for most producers (Irrigation Water Management Study Committee 2002). The time series of annual demands and deficits shows all demands and all deficits for the 1928 to 1995 simulation period. The amount of water that can be applied even in drought years when there are deficits, and the troublesome back-to-back

Priorities. Water use priorities under the *Water Act* are based on the date of a completed license application. Each license issued in the study area has a unique priority. In water-short years, users are cut off in order of junior to senior licence priority. Modeling conducted on the H/LB system does not address the priority of each individual license. Water demands of licensees are accumulated along stream reaches, assigned to the upstream node, assigned a priority in relation to other demand blocks, and treated as a single demand. Assigned priorities reflect reality insofar as possible, however they are subject to modeling practicality and convenience. For instance, non-irrigation demands are small relative to irrigation demands (almost to the extent of being insignificant in the Little Bow Basin). These demands are assigned the highest priority in the model since they generally do not have a large effect on the performance of the system. However, in actual operation and enforcement, low priority non-irrigation demands face the same risks as irrigation users in times of water shortages.

deficits are readily apparent in the time series.

The habitat indices for aquatic ecosystem health (Table 4) are for Mountain Whitefish Adult (most sensitive species and life stage) for Reach 4, Aldersyde to Sheep River confluence (most sensitive reach downstream of the diversions). To help put the affected area into perspective, the Highwood River reach affected by the diversions represents 28 percent of the total length of the Highwood River, 16 percent of the total length of Highwood and Sheep Rivers, five percent of the length of Highwood, Sheep and tributaries, and 37 percent of length of the Highwood downstream of Pekisko Creek and Sheep downstream of Turner Valley (Golder 2003).

The Upper Little Bow River will experience channel widening and loss of some existing vegetation in the initial years of operation. The performance indicators apply to the period after the initial channel adjustments.

Table 4 Performance parameters and criteria.

Issue	Indicator Parameter	Measure	Criteria
Consumptive Uses	Irrigation deficits	% of years deficits > 100mm. Time series of demands and deficits.	Deficits $\leq$ pre-project conditions. No back-to-back deficits > 100 mm. Comparative analysis.
Aquatic Ecosystem Health	Fish habitat	Overall average habitat (Apr to Oct inc.). July 16 to Aug 31 average habitat. Max yearly reduction from natural Max weekly reduction from natural	Habitat $\geq$ Base Case habitat. Comparative analysis.
Water Quality	Minimum flow indicators	Highwood T and DO flow ≥ 8.0 m^3/s. Upper L. Bow DO flow ≥ 1.11 m^3/s.	Comparative analysis.
Riparian Vegetation	River stages patterns	River stages and down-ramping for regeneration, survival and growth.	Comparative analysis.

4.3 The Scenarios

Scenarios were formulated and modelled for a number of purposes.

- To verify that model parameters, such as penalty points, are set correctly and the model is operating as intended.
- To calibrate the model to assure that it is representative of the physical system.
- To establish a Base Case for comparison purposes.
- To explore various aspects of the system that help to design or evaluate options.
- To explore options for future developments and operations.
- To test the sensitivity of various assumptions used in model runs.

It was assumed that operation of the diversion works to meet pre-Little Bow Project licences was fixed for all scenarios by licence priorities and past practices. **Water management variables** for new scenario formulations were primarily the operating guidelines for the diversion works to meet post-project demands and storage requirements. The variables included variations of the IFN for the Highwood River, the minimum operating flows for the Upper Little Bow River and Mosquito Creek, the operation of the Twin Valley Reservoir, the level of non-irrigation demands, and new storage development at Women's Coulee.

General thrusts in formulating and running scenarios follows.

4.3.1 Base Case Development

The Base Case scenario is representative of pre-Little Bow Project conditions (circa 2001). It serves as a basis for comparison, which is important for three primary reasons:

- To calibrate the model.
- To ensure that no pre-project licensees are worse off with the project than they were without the project.
- To provide a measure of pre-project fishery habitat that can be used to address Fisheries and Oceans Canada's No Net Loss Guiding Principle (sidebar).

Eight scenarios were developed and analyzed to develop a Base Case scenario and test the sensitivity of related assumptions. Issues included the following.

- Whether or not to assume that irrigation licences with July cut-offs would be extended.
- Whether or not to consider inactive projects were operating.
- Whether or not the licence allocation should be adhered to as the upper limit of withdrawals when crop water requirements exceed the licence allocation.
- The impact of temperature and dissolved oxygen criteria in the 1994 Diversion Guidelines.

No Net Loss Principle
Under authority of the Fisheries Act, Fisheries and Oceans Canada (DFO) is responsible for the conservation and protection of fish and fish habitat. Section 35 of the Act prohibits the harmful alteration, disruption or destruction of fish habitat without Ministerial approval and assigned terms and conditions that would allow the project to proceed.

In reviewing proposed projects, DFO applies the No Net Loss Principle as a guide for habitat management decisions. Under this principle, DFO works with project proponents and provincial agencies so that projects are designed in a way that maintains the productive capacity of fish habitat. Pre-project habitat conditions serve as a basis for determining the impact of a project on fish habitat.

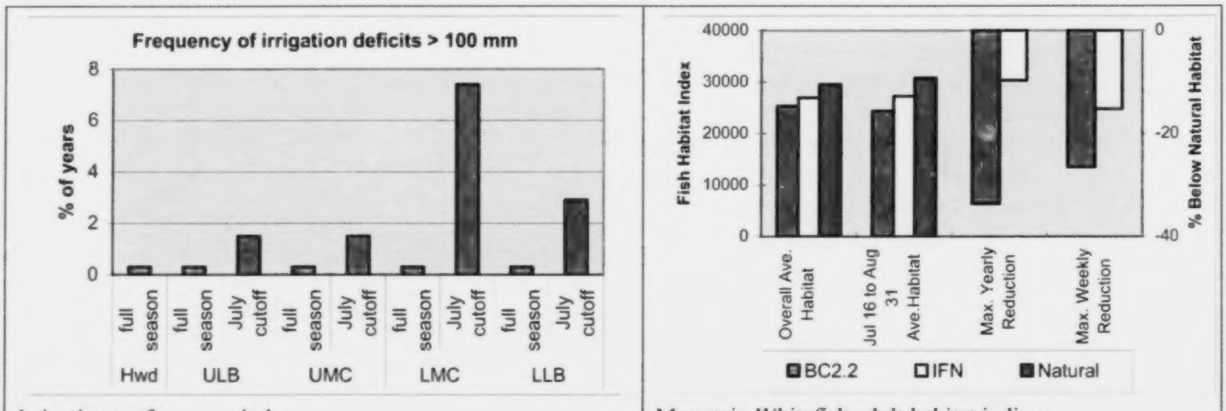
(DFO 1998)

Scenario BC2.2 was selected as being the most representative of pre-project conditions. Priorities and assumptions in the Base Case scenario are as follows.

- Priorities assumed for modelling purposes were in keeping with legal requirements within limitations of the model (priorities sidebar). Priorities were assumed to be as follows:
  a) Existing Highwood, Little Bow and Mosquito Creek non-irrigation demand.
  b) Existing Highwood irrigation demand.
  c) 1994 Operating Guidelines.
  d) Existing Little Bow and Mosquito Creek full season irrigation demands.
  e) Existing Little Bow and Mosquito Creek irrigation demands with July cut-off dates.
  f) Operating minimum flows of 20 cfs year-round for the Little Bow, and 10 cfs during non-winter months for Mosquito Creek.
  g) Inflow to Travers Reservoir 20 cfs year-round.
- Non-irrigation water use was based on Year 2001 level of demand (Year 2001 population, industrial development, etc.).
- Irrigation demand was based on Year 2001 active projects only. Demand was variable year-to-year, depending on weather conditions.
- For irrigation projects that had licences with July cut-offs, it was assumed that the cut-offs would be extended, subject to 1994 guidelines. (In actual operation, the licensees with cut-offs were often granted extensions to allow continued irrigation after the cut-off date when sufficient water was available.)
- Subject to water supply constraints, the project is operated to fully meet demands or the licence allocation, whichever is less.

Modelling output for BC2.2 indicates that there would be irrigation deficits greater than 100 mm in less than 10 percent of the years in all sub-basins (Figure 3). The highest frequency of deficits greater than

100 mm occurred in Lower Mosquito Creek Sub-basin in the cut-off irrigation blocks. Deficits greater than 100 mm would occur in about 7.5 percent of the years (on average, one year in eight). Figure 3 shows the time series of irrigation demands and deficits for the Lower Mosquito Creek Sub-basin. Most of the shortages occur in the 1930s and 1980s.



Irrigation performance index.

Mountain Whitefish adult habitat indices.

Figure 3 Irrigation and fish habitat performance for Base Case Scenario BC2.2.

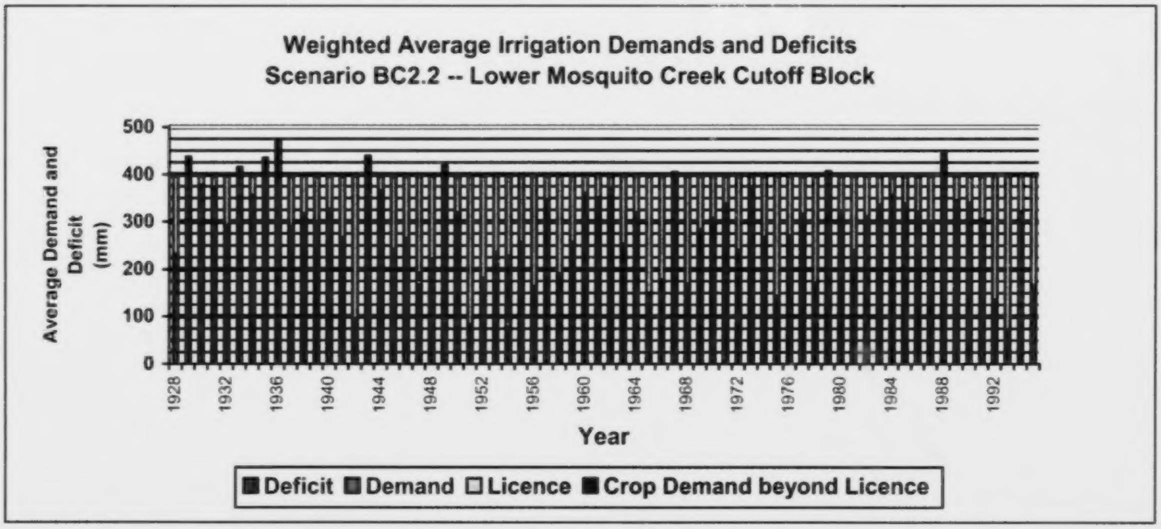


Figure 4 Lower Mosquito Creek cut-off block irrigation performance time series for Scenario BC2.2.

Adult Mountain Whitefish habitat indices (the most sensitive species and life stage) for Scenario BC2.2, the recommended technical IFN and natural conditions are shown on Figure 3. The performance for the Base Case scenario is poorer than that of the recommended technical IFN particularly for the maximum reductions in habitat. Diversions to meet pre-Little Bow Project licence commitments encroach on the recommended IFN.

Base Case performance will be used as a basis for comparison on graphics displaying the performance of other scenarios.

4.3.2 Interim Operating Plan

The Interim Operating Plan (IOP) is a plan developed by Alberta Infrastructure and Transportation to be used for operating the project for a short period prior to development and acceptance of an Interim Diversion Plan or the Highwood Diversion Plan. The IOP was developed in October 2002 (IDP2.1) and was used during the 2003 operating season. It was revised in March 2004 (IDP2.1.1) for use in the 2004 operating season.

The Diversion Rule for Scenario IDP2.1 was based on the comments and recommendations of the Joint Review Panel (JRP) at the Public Hearings held in 1997 and 1998.

- April 1 to July 15: Highwood IFN equals 80 percent Fish Rule Curve; water temperature < 21 C; flushing flows (as proposed by Alberta Infrastructure and Transportation in the project EIA).
- July 16 to August 31: Highwood IFN equals 85 percent of natural flow down to a base flow, as recommended by the Highwood IFN Technical Working Group.
- September 1 to October 31: Highwood IFN equals 80 percent Fish Rule Curve; water temperature < 21 C; flushing flows (same as April 1 to July 15).
- November 1 to March 31: 1994 Highwood River Diversion Guidelines.

Scenario IDP2.1 assumed no extensions for the irrigation licences with July cut-offs. The March 2004 revision (IDP2.1.1) assumed that the cut-offs would be extended if sufficient water was available. This was the primary difference between IDP2.1 and IDP2.1.1.

The performance of Scenarios IDP2.1 and IDP2.1.1 at full development of irrigation showed few irrigation deficits (none greater than 50 mm), average fish habitat similar to BC2.2, but significantly inferior habitat for short periods. However, the performance at full development is not a significant issue. The Interim Operating Plan was intended only for short-term use. It will probably be superceded by a more permanent and comprehensive plan prior to full development of irrigation expansion.

4.3.3 Interim Diversion Plan: Approach

Initial efforts of the Modelling Focus Group, a sub-committee of the Public Advisory Committee, were to develop an Interim Diversion Plan (IDP). The IDP would be based on the best compromise scenario for meeting objectives of the project without new storage development. An IDP was required to operate the project until new storage options were fully assessed, the approval processes completed, construction completed, the reservoir was filled and operation of the storage project commenced. When the IDP was developed and all new storage options assessed, the PAC could then focus on operation of the project with storage in place. The improvement in performance in meeting objectives with storage in place over that of the IDP would be indicative of the value of the new storage. If new storage proved to be infeasible or ineffective in meeting objectives, the IDP could become the Highwood Diversion Plan, unless some other options emerged.

The Modelling Focus Group's approach toward developing the IDP was to start with a scenario that would best meet the recommended technical IFN, and then encroach on the recommended IFN in successive iterations until satisfactory performance in meeting consumptive uses was attained. Encroachments on the recommended IFN were made in a manner that was judged to have least impact on Highwood River fishery habitat.

4.3.4 Interim Diversion Plan: Fish Habitat Emphasis

A series of eight scenarios were formulated and run to explore the implications on performance of the recommended technical IFN, and minor variations of the technical IFN that would not appreciably affect fish habitat. The variations tested reduced the Highwood instream flows under high flow conditions (greater than 800 cfs). Reduced levels of irrigation expansion in the Lower Little Bow Sub-basin were also considered in an attempt to improve habitat performance.

The most favourable option that considered full irrigation expansion was Scenario IDP2.3.2. Fish habitat performance was similar to that of the scenario with the full technical IFN. Irrigation deficits for Scenario IDP2.3.2 were high and frequent in the Clear Lake and Lower Little Bow expansion blocks (Figure 5). Deficits greater than 100 mm were experienced in the Clear Lake block in about 18 percent of the years, and in the Lower Little Bow block in about 14 percent of the years. Figure 6 shows that there would be many back-to-back deficits greater than 100 mm, a situation that irrigation farmers feel it is essential to avoid.

Highwood fishery performance for Scenario IDP2.3.2 was as good as possible within the constraints of pre-Little Bow Project licences and priorities. Fishery performance was better than Base Case for all metrics but fell considerably short of performance for the full recommended technical IFN due to pre-Little Bow Project licence commitments (Figure 7).

4.3.5 Interim Diversion Plan: Best Compromise Performance Without Drought Operation Rules

Twenty-one scenarios were run to find the best compromise scenario that would meet project objectives for Little Bow Project irrigation expansion and retain as much of Scenario IDP2.3.2 fish habitat benefits as possible. The series progressively encroached on Scenario IDP2.3.2 fish habitat by modifying the diversion rule curve under high flow conditions until it was felt that any further encroachment would impact on Base Case fish habitat. Scenario IDP2.5.2.3 was judged to be the best compromise scenario.

The Highwood River instream requirement for Scenario IDP2.5.2.3 is a variation of the IFN recommended by the Highwood Instream Flow Needs Technical Working Group (Figure 8). The adjustment from the recommended Highwood IFN to the Highwood Instream Objective Rule #3 (IO Rule #3) was made to reduce Lower Little Bow and Clear Lake irrigation expansion deficits. The adjustment encroached on the recommended IFN during high flow periods, but did not impact fish habitat during low flow periods. One additional measure was taken to reduce deficits in the Clear Lake expansion block. The minimum operating flow target was increased to 20 cfs from 10 cfs for the period April 15 to June 25 to increase storage at Clear Lake.

Scenario IDP2.5.2.3 was considered to be the best compromise scenario possible without forecasting and special operations during droughts. Irrigation performance in the Clear Lake and Irrigation performance in the expansion blocks for Scenario IDP2.3.2.3 was much improved over that of Scenario IDP2.3.2 (Figure 9). However, deficits greater than 100 mm in the Clear Lake expansion block would still occur in about 10 percent of the years, including back-to-back years in the 1930s and 1980s (Figure 10). Irrigation deficits in the Lower Little Bow expansion block would be less frequent, but would include large back-to-back deficits in the 1980s (Figure 10). Note that performance in all other reaches for IDP2.5.2.3 would be the same as shown for Scenario IDP2.3.2 in Figure 5.

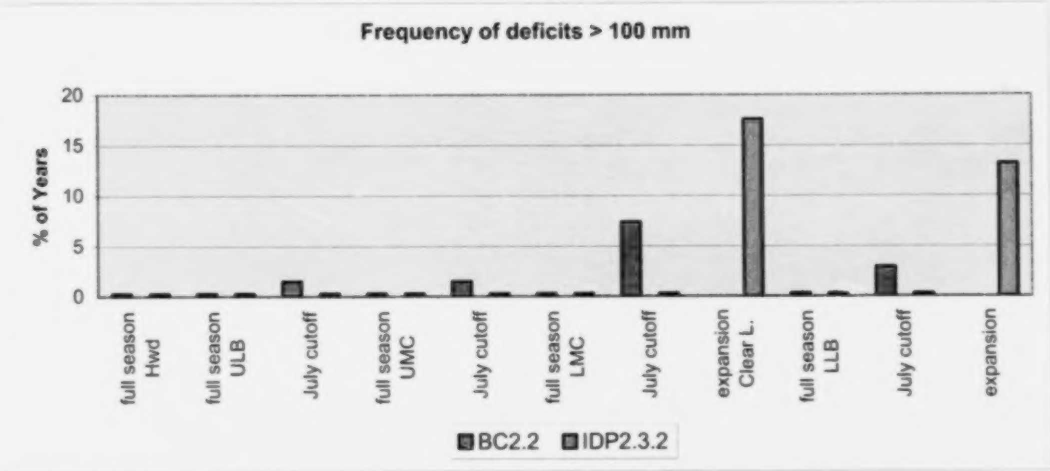


Figure 5 Irrigation performance index for Base Case and Scenario IDP2.3.2 with Highwood fish habitat emphasis.

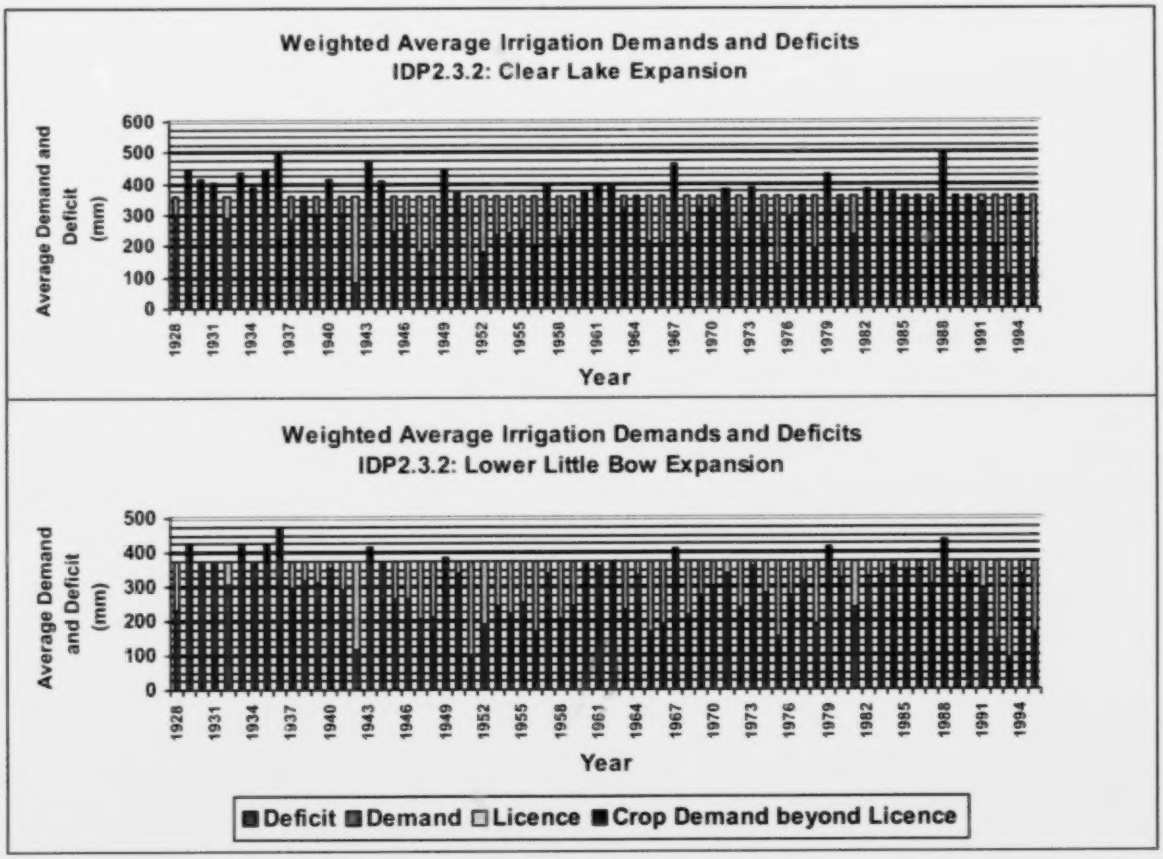


Figure 6 Scenario IDP2.3.2 irrigation performance time series for expansion blocks.

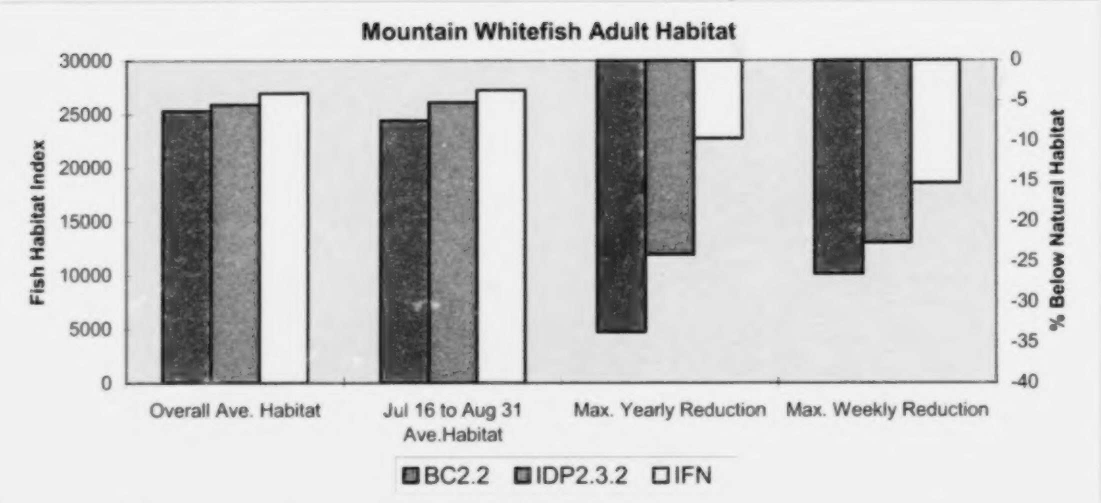


Figure 7 Fish habitat performance for Scenario IDP2.3.2.

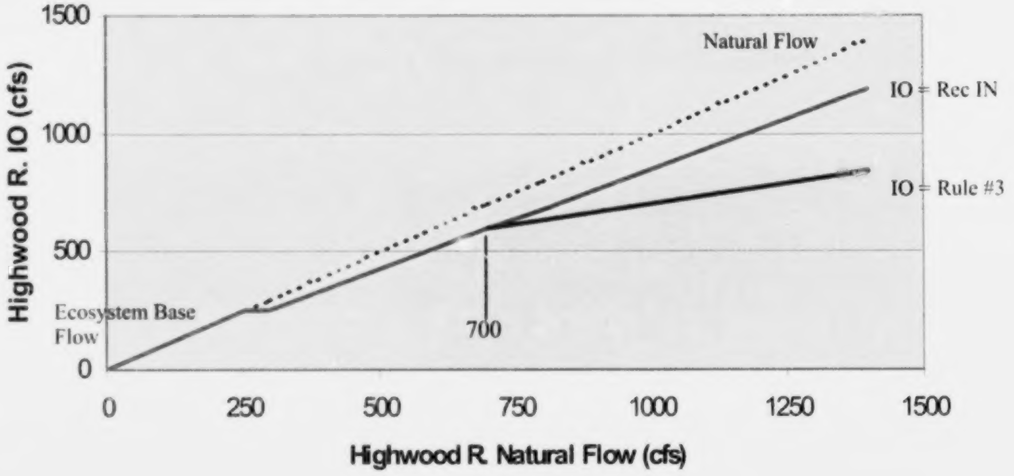
Fishery habitat was not evaluated for Scenario IDP2.5.2.3 pending input from the irrigation community. However, it was believed that habitat would not be significantly different from the Base Case (Base Case is shown on Figure 7).

Scenario IDP2.5.2.3 was reviewed with the irrigation community at Champion on April 11, 2003. The irrigators indicated that occasional deficits greater than 100 mm could be tolerated, but back-to-back deficits of that magnitude should be avoided. The Clear Lake expansion irrigators were concerned about both the magnitude and frequency of irrigation deficits. They were also concerned about back-to-back deficits greater than 100 mm in the 1930s and 1980s. The Lower Little Bow expansion irrigators indicated that the large back-to-back deficits in the 1980s would be a serious problem.

The irrigators suggested that a drought operation procedure be developed and implemented only during prolonged droughts specifically to avoid large back-to-back deficits. It was suggested that consumptive users could absorb the first year of a large deficit, but the impact of a second and third year deficit should be shared by instream habitat and consumptive users.

4.3.6 Interim Diversion Plan: Drought Operation Rules

Development of a drought rule for the Highwood/Little Bow system involved two steps. Firstly, a "trigger" rule was required to define conditions when the drought operational plan would come into effect. Secondly, the deviations from the "normal" operation plan that would result in improved irrigation performance while minimizing encroachment on Highwood River fish habitat had to be defined. A detailed discussion of the trigger and the drought operation rules is provided in the Fact Sheet, **Drought Period Operation Procedures** (Hart 2004; Compendium).



Notes: 1. The Ecosystem Base Flows vary weekly. For instance, for the week April 23 to April 29, they are all flows up to 207 cfs; for the week July 16 to July 22, they are all flows up to 352 cfs.

2. For Scenario IDP8CS1, the Rule Curve deviates from the red line at Qnat = 700 cfs and follows the green line (IO Rule #3). At Qnat = 1400 cfs, the IO for Rule #3 = 0.60 Qnat or 840 cfs.

3. The difference between the natural flow line and the particular IO line that is under consideration in the scenario represents the flow available for consumptive use along the Highwood River and for diversion to the Little Bow Basin through the Women's Coulee and Little Bow Diversions.

Note: Imperial units are used in this Figure (1.0 m^3/s = 35.315 cfs).

Figure 8 Highwood Instream Objective (IO) Rule # 3: a variation of the technical recommended IFN used in Scenario IDP2.5.2.3.

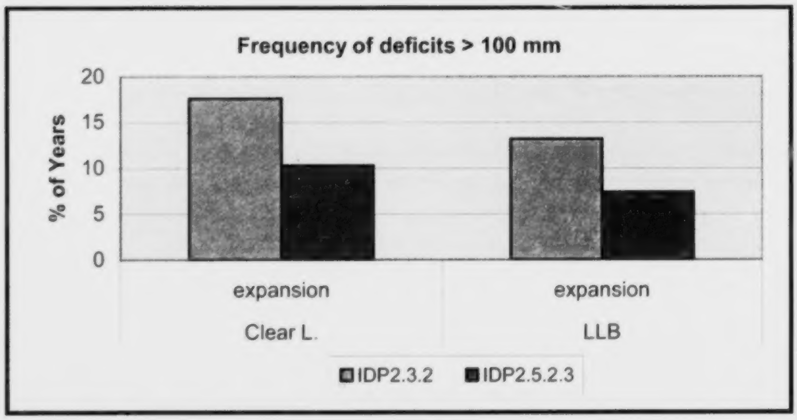


Figure 9 Irrigation performance for Scenario IDP2.5.2.3

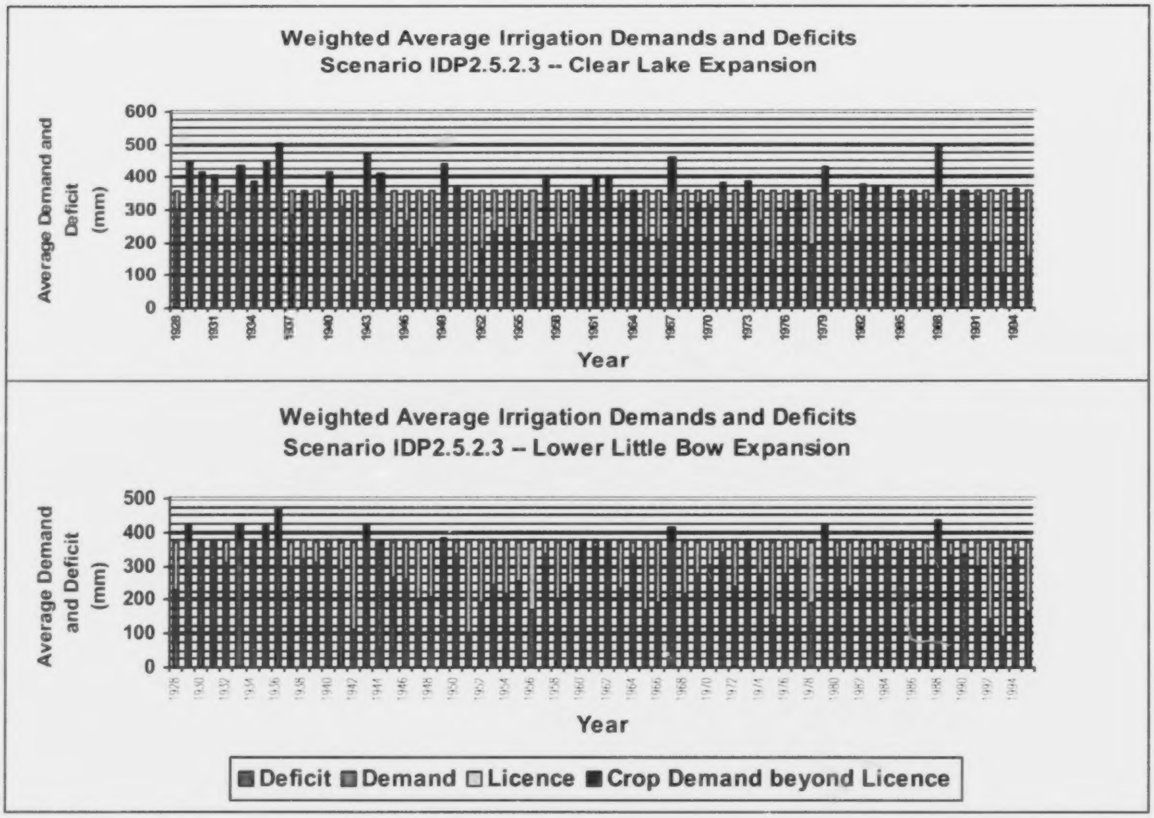


Figure 10 Scenario IDP2.5.2.3 irrigation performance time series for expansion blocks.

- **The Trigger Rule**

The trigger rule must be developed using data that would be available or could be estimated in real-time operations. Performance success in the Highwood/Little Bow system is primarily dependent on Highwood River streamflow during the summer period and the amount of storage in Clear Lake and Twin Valley Reservoirs in early May. In real-time operations, Highwood River March 1 to September 30 flow volumes are routinely estimated by AENV's River Forecast Centre.

From analyses of scenarios that did not incorporate drought operational rules, it was found that deficits greater than 100 mm had some common runoff and storage pre-conditions (Table 5). These pre-conditions became the trigger rules. Separate rules were developed for the Women's Coulee Diversion and the Little Bow Diversion. Drought operations were triggered in 10 years for the Clear Lake expansion block, and in four years for the Lower Little Bow expansion block.

- **The Drought Operation Rules**

The objective of the drought operation procedures is to modify the normal operation plan during severe droughts by increasing inflow to Clear Lake and Twin Valley Reservoirs by amounts sufficient to eliminate 100 mm back-to-back deficits in the expansion blocks. Increasing diversions during the high runoff period by modifying the operational flow targets would build storage at Clear Lake and/or Twin

Table 5 Trigger rules for drought period operation procedures.

Diversion	Implement Drought Operation Rules If:			
	Mar 1 to Sept 30 Volume Forecast as of May 1 is:		Reservoir Level on May 1 is:	
			Clear Lake Res.	Little Bow River Res.
Women's Coulee	$< 300,000$ dam^3 **OR** $< 400,000$ dam^3	**AND**	< 965.0 m	
Little Bow	$< 400,000$ dam^3	**AND**		< 957.0 m

Valley Reservoir so the demands could be better met by releases from storage during the low runoff period.

Several trials were made by incrementally modifying the minimum operational flow targets for Mosquito Creek and the Upper Little Bow River before arriving at the magnitude and period of adjustments that would satisfy the objectives. Table 6 shows the operational flow targets under the normal operation plan and under the drought operation procedure for Scenario IDP8CS1. All other aspects of the operation remain the same. The objectives were met by modifying the minimum operational flow target for Mosquito Creek downstream of the Clear Lake Diversion to 0.850 m^3/s from 0.283 m^3/s (to 30 cfs from 10 cfs), and for the Upper Little Bow upstream of the Twin Valley Reservoir to 2.124 m^3/s from 0.850 m^3/s (to 75 cfs from 30 cfs). Both modifications were made for the period May 1 to July 15, which is normally the high flow period.

Minimum operational flow targets are base flows required to meet conveyance losses, keep the stream live to meet needs for traditional agricultural uses and other non-irrigation uses, and assist in maintaining water quality. They have a higher priority than the new Highwood River instream objectives (or some variation thereof) recommended by the IFN Technical Working Group.

4.3.7 Interim Diversion Plan: Best Compromise Performance with Drought Operation Rules

Ten scenarios were tested in this series. Scenario IDP2.5.2.9.8CS1, hereinafter referred to as Scenario IDP8CS1, was judged to be the best scenario for meeting consumptive needs without impacting on Base Case fish habitat.

Scenario IDP8CS1 varied from Scenario IDP2.5.2.3 as follows.

- Upper Little Bow normal minimum operating flow target increased from 0.566 m^3/s to 0.850 m^3/s (20 cfs to 30 cfs) from May 1 to Sept 30. The primary reason for the increase is to improve water quality (operating flow targets change during droughts).
- Mosquito Creek normal minimum operating flow target was reduced from 0.566 m^3/s to 0.566 m^3/s (20 cfs to 10 cfs) during summer operating period.
- Scenario IDP8CS1 incorporates a drought operation plan for low runoff year operations.

Table 6 Modification of the normal operating plan for drought periods (IDP8CS1).

Stream Reach	Minimum Operating Flow Target			
	Apr 1 – Apr 30	May 1 – Jul 15	Jul 16–Sept 30	Oct 1 – Mar 31
Little Bow R. U/S Twin Valley Reservoir				
Normal Operations	0.566 m^3/s	0.850 m^3/s	0.850 m^3/s	0.566 m^3/s
Drought Operations	0.566 m^3/s	2.124 m^3/s	0.850 m^3/s	0.566 m^3/s
Little Bow River U/S Travers Reservoir	0.566 m^3/s	0.566 m^3/s	0.566 m^3/s	0.566 m^3/s
Mosquito Cr D/S Clear L. Diversion				
Normal Operations	0.283 m^3/s	0.283 m^3/s	0.283 m^3/s	0.283 m^3/s
Drought Operations	0.283 m^3/s	0.850 m^3/s	0.283 m^3/s	0.283 m^3/s
Mosquito Cr U/S Twin Valley Reservoir	0.283 m^3/s	0.283 m^3/s	0.283 m^3/s	0.283 m^3/s

Operating Season -- For modeling purposes, the operating season for the diversions have been defined as April 1 to October 31. In actual operation, initiation and termination of seasonal operations will be defined by weather conditions and flows.
Units -- Flow rates provided in m^3/s only ($1.0\ m^3/s = 35.315$ cfs).
Increased May 1 to July 15 minimum operating flow targets are required to increase storage in Twin Valley and Clear Lake Reservoirs during drought years.

- Extensions of the July irrigation cut-offs in the Upper Little Bow and Mosquito Creek Sub-basins were made subject to the minimum operational flow targets.

Irrigation performance for Scenario IDP8CS1 was much improved over IDP2.5.2.3 (Figures 11, 12 and 13). There were fewer deficits over 100 mm, and no back-to-back deficits of that magnitude.

Fish habitat for Scenario IDP8CS1 was equal to or slightly better than the Base Case for all four metrics (Figure 14). It was not as good as Scenario IDP2.5.2.3 primarily due to higher minimum operating flow target for the Upper Little Bow.

The Management Sub-committee of the Highwood Public Advisory Committee decided that Scenario IDP8CS1 meets the objectives of the Highwood Diversion Plan to the extent possible without constructing addition storage. The remaining task was to assess the extent to which additional storage in Women's Coulee would improve performance in meeting objectives.

4.3.8 The Benefits of Additional Storage Development

Five scenarios were run assuming the Super Expanded Women's Coulee Reservoir was in place. The objective was to determine the improvement in fish habitat that would be attainable with the new reservoir. Scenario 9EWC4.1 best represented the operation of the system with additional storage. Assumptions were as follows:

- New storage reservoir in Women's Coulee with a capacity of 14,700 dam^3.
- Enlarged inlet canal with a capacity of 3.4 m^3/s.
- New pipeline to return flow from Women's Coulee Reservoir to the Highwood River with a capacity of 2.3 m^3/s.

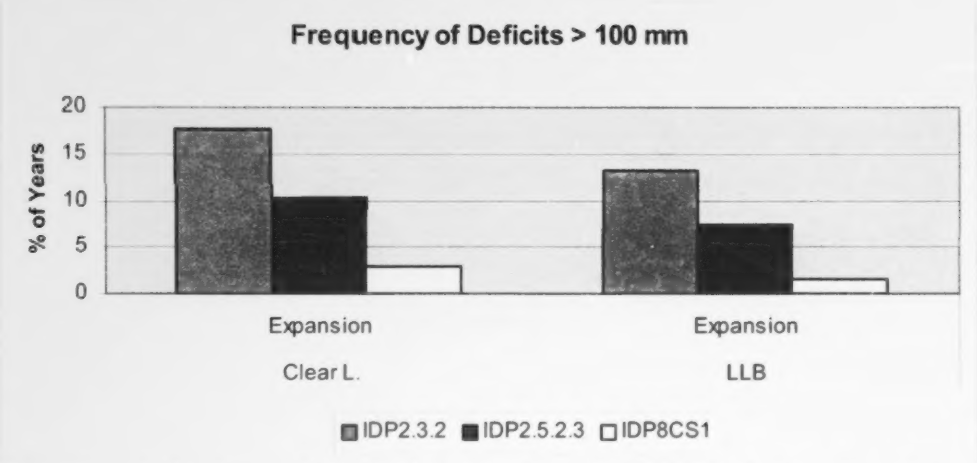


Figure 11 Irrigation performance index for Scenario IDP8CS1: best compromise scenario with drought operation rules.

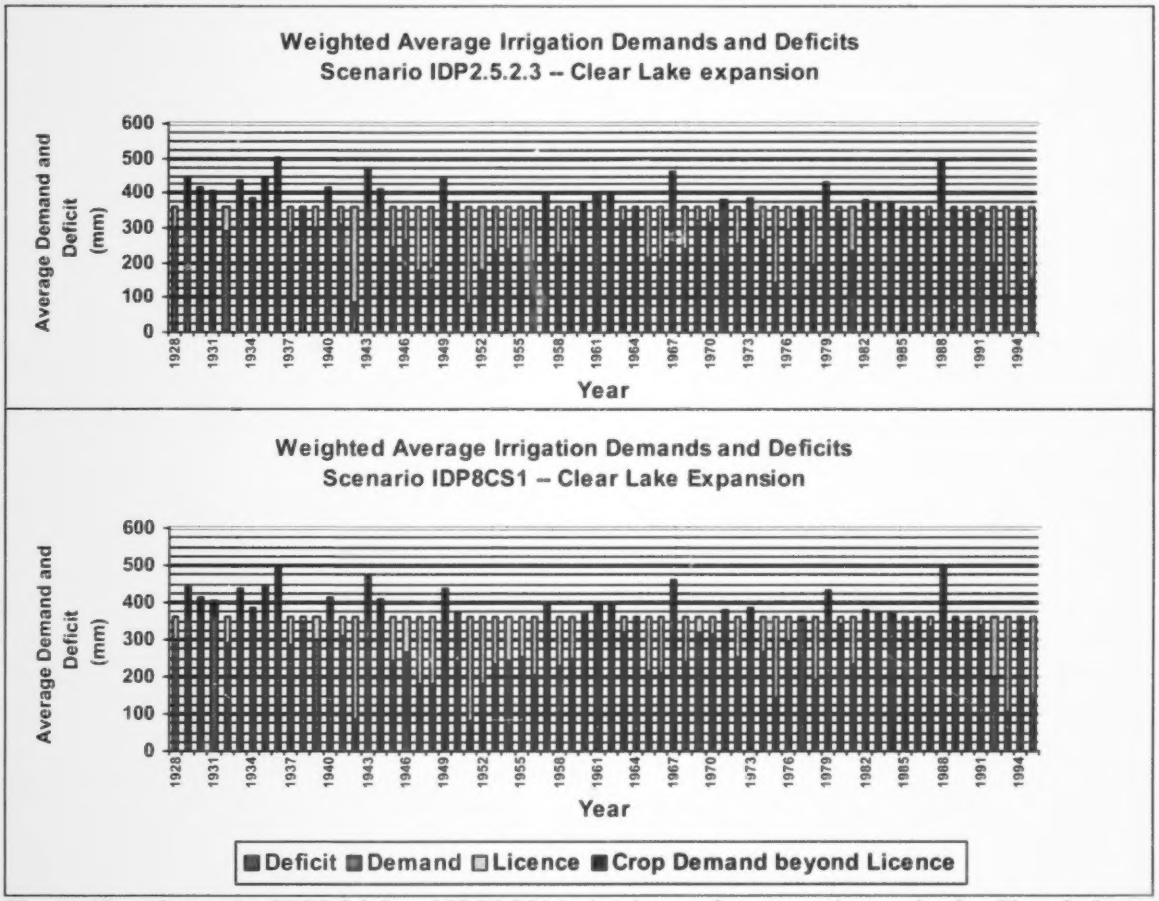


Figure 12 Scenarios IDP2.5.2.3 and IDP8CS1 irrigation performance time series for Clear Lake expansion block.

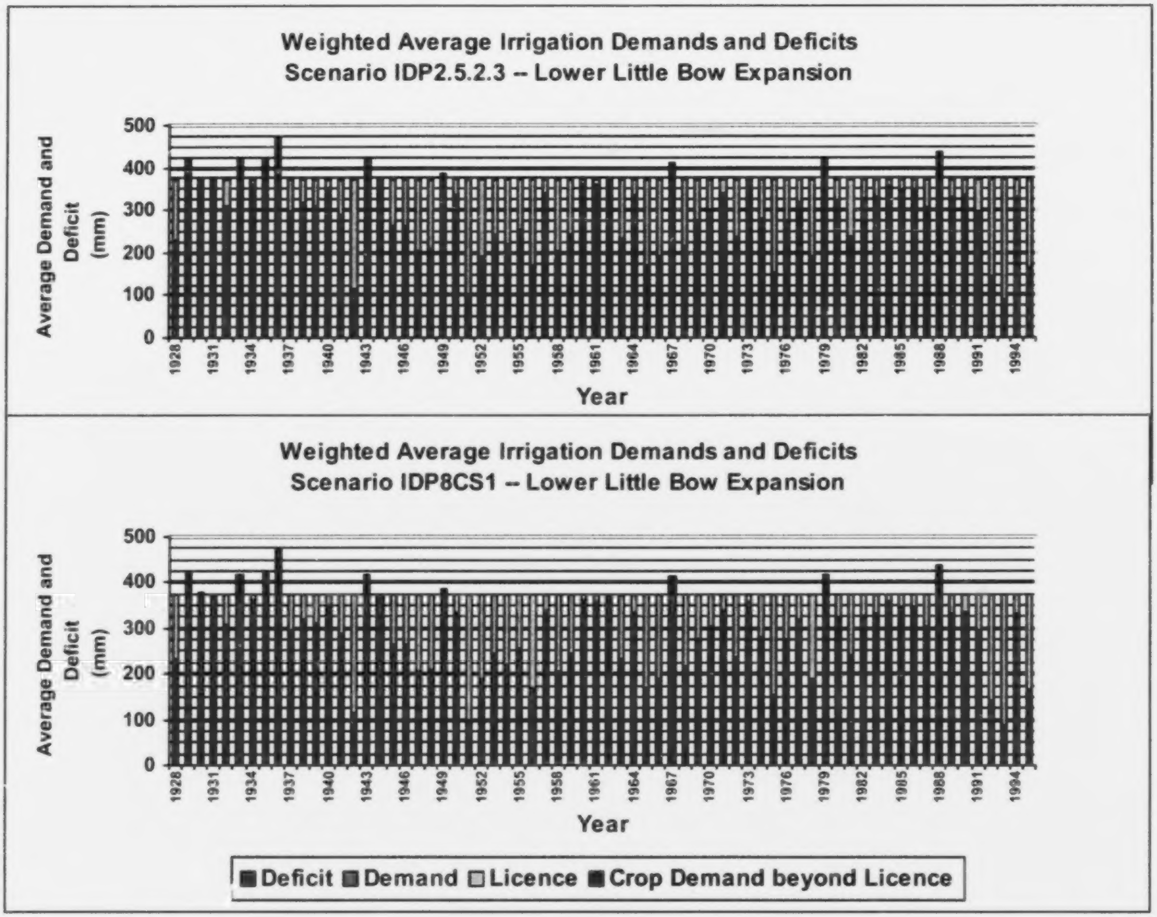


Figure 13 Scenarios IDP2.5.2.3 and IDP8CS1 irrigation performance time series for Lower Little Bow expansion block.

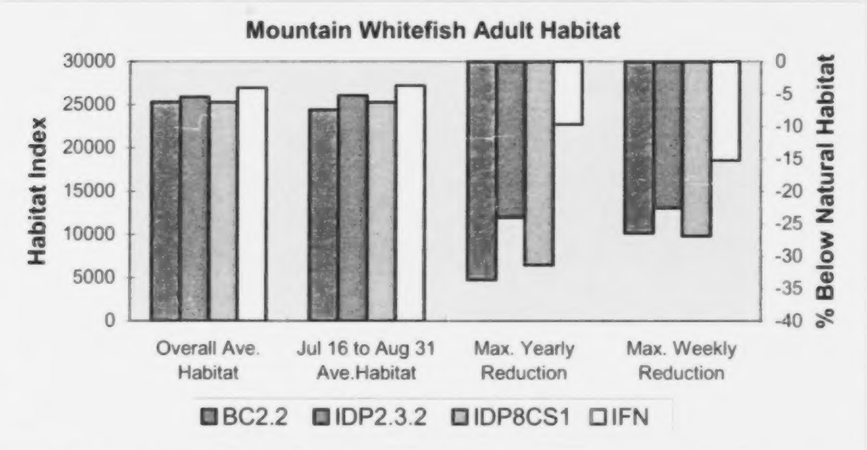


Figure 14 Comparative fish habitat performance for Scenario IDP8CS1.

- Operation of the reservoir would be dedicated solely toward improving instream flow conditions on the Highwood River over those for Scenario IDP8CS1. In other words, the Women's Coulee Reservoir would not be used to reduce deficits to consumptive users that were experienced with Scenario IDP8CS1.

Modelling indicated that expanding Women's Coulee Reservoir, increasing the capacity of its inlet canal, and providing a return canal back to the Highwood River would not significantly improve instream flow conditions along the Highwood River. Figure 15 shows the mountain whitefish adult habitat for four metrics. There is only a minor improvement in habitat attributable to the Super Expanded Women's Coulee storage (Scenario IDPEWC4.1) compared with the best scenario without the additional storage (Scenario IDP8CS1). Figure 16 graphs annual habitat availability for each of the years modelled. It demonstrates a minor increase in habitat in average and higher flow years, but little or no difference in low flow years. Since these years are the ones in which habitat is most likely to be limiting to fish populations, the added storage appears to have very little value for improving fish habitat.

This finding is markedly at variance with the findings of earlier modeling efforts. Some of the changes in the conclusions are related to improvements in modelling that have occurred over time resulting in a more accurate assessment. However, the main reasons relate to the revised approach to determining instream flow needs (Clipperton et al. 2002). Earlier work had determined that there was adequate flow in the Highwood River to supply an additional 17,000 dam^3 of storage on a relatively reliable basis. This determination was based on the instream flow needs proposed as part of the project application to the NRCB. However, under NRCB Order 9601-01, the Joint Review Panel instructed Alberta Infrastructure and Transportation to "revise the IFN analysis used in the Application to reflect current fisheries management objectives for the Highwood River and to include instream flow needs based on the most recent information regarding the River, and current scientific assessment procedures."

In the years since the NRCB Order, the Government of Alberta has radically changed the approach taken to establishing instream flow needs. The newer approach attempts to mimic the natural variability of the stream. The revised instream flow needs recommendation is based on a proportion of the natural flow for the entire hydrologic regime, which restricts the ability to divert water even during relatively high flow

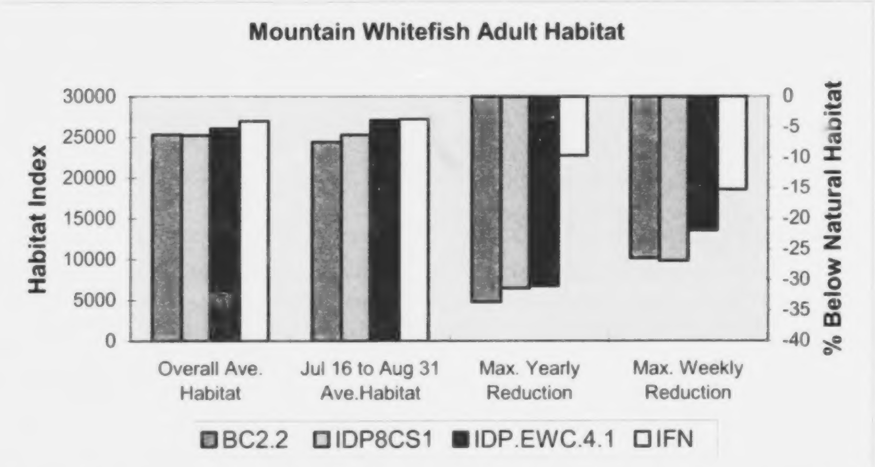


Figure 15 Comparative fish habitat performance for Scenario IDPEWC4.1.

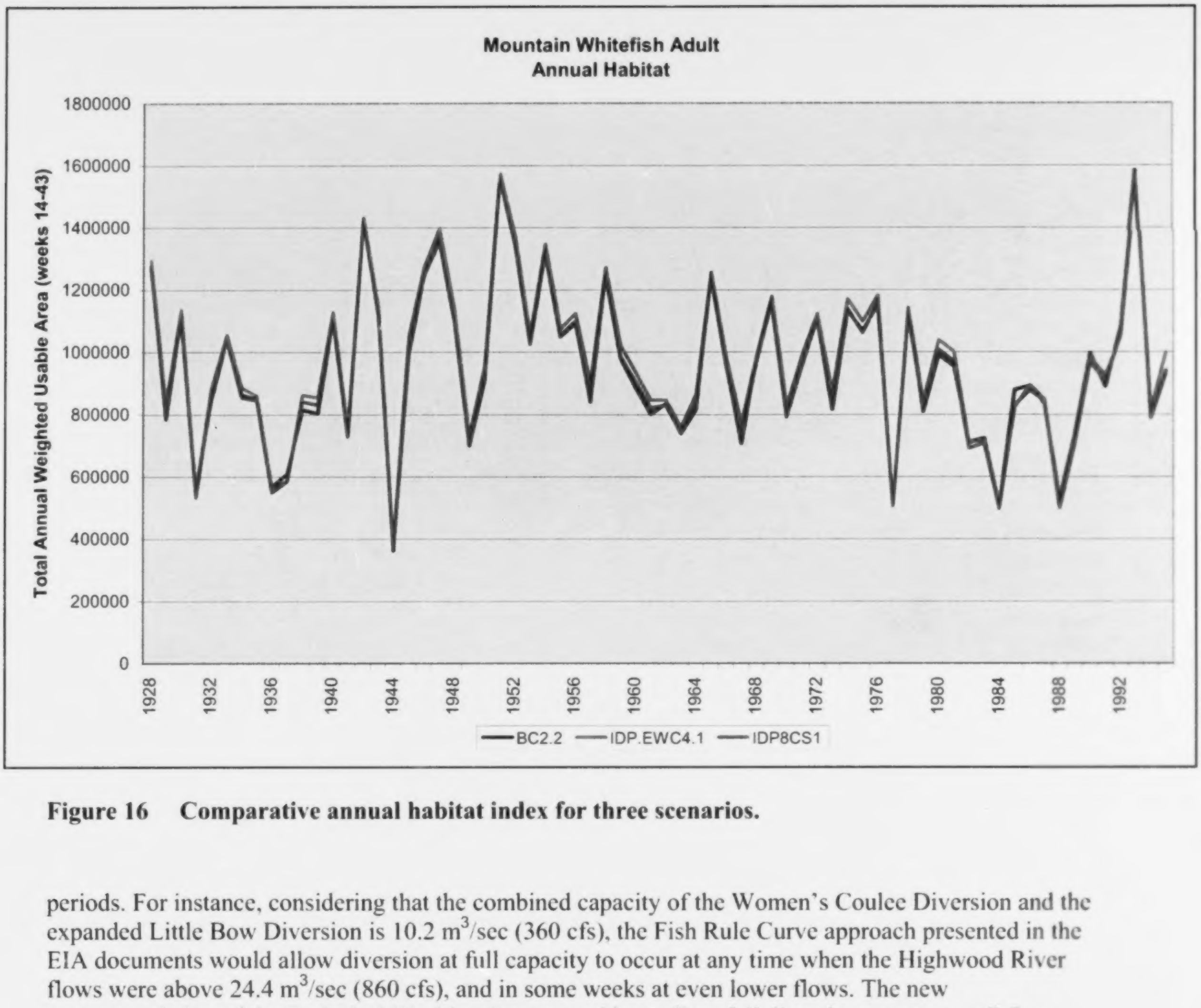


Figure 16 Comparative annual habitat index for three scenarios.

periods. For instance, considering that the combined capacity of the Women's Coulee Diversion and the expanded Little Bow Diversion is 10.2 m^3/sec (360 cfs), the Fish Rule Curve approach presented in the EIA documents would allow diversion at full capacity to occur at any time when the Highwood River flows were above 24.4 m^3/sec (860 cfs), and in some weeks at even lower flows. The new recommendation of the Technical Working Group would not allow full diversion to occur until flows reached 68.0 m^3/sec (2400 cfs). Instream Objective Rule 3 used in Scenario IDP8CS1, which encroaches on the recommended instream flow needs, allows more water to be diverted at higher flow periods when diversions have a lesser effect on fish habitat. Rule 3 permits full diversion at flows of 31.1 m^3/sec (1100 cfs). Additional information related to the flow available for diversion to storage in the Fact Sheet, **Review of Additional Storage** (Middleton 2004; Compendium).

The PAC felt that the minimal improvement in fish habitat on the Highwood River did not justify the social and environmental disruption, and the high cost of a large Women's Coulee reservoir. For this reason, the Public Advisory Committee does not support construction of the reservoir for the intended purpose.

Pending public input, the PAC decided to recommend to Alberta Environment and the Natural Resources Conservation Board that Scenario IDP8CS1 provide the basis for development of the Highwood Diversion Plan. The draft recommendations that were developed for public review are included in this report as Appendix B.

5.0 Characteristics and Performance of Scenario IDP8CS1

Scenario IDP8CS1 has been judged by the Highwood Management Plan Public Advisory Committee (PAC) as the diversion plan that best meets the objectives of the Highwood/Little Bow Project without new storage development, and without negatively impacting pre-project water users while sustaining existing Highwood fishery habitat conditions. Pre-Little Bow Project conditions are characterized by the Base Case Scenario (BC 2.2) and are embodied in the development of Scenario IDP8CS1. Pending broader public input, the PAC is prepared to recommend that Scenario IDP8CS1 form the basis for development of the new Highwood Diversion Plan that will serve as guideline for the water management diversion operations on the Highwood/Little Bow system.

Scenario IDP8CS1 has the following key characteristics and performance.

5.1 Key Characteristics

5.1.1 Recognizes licensed water use projects and Little Bow Project water use expansion.

All active and inactive licensed projects are considered to be operating. Irrigation expansion at Clear Lake (1416 ha or 3500 acres) and in the Lower Little Bow Sub-basin (6677 ha or 16,500 acres) is assumed to be in place and operating.

5.1.2 Grants extensions to licenses with July cut-off dates.

All July cut-off dates are assumed to be removed. It was assumed that water use after the cut-off date would remain subject to the 1994 Guidelines, and to minimum operating flow targets of, during normal operations, 0.850 m^3/s (30 cfs) along the Upper Little Bow River, 0.566 m^3/s (20 cfs) along the Lower Little Bow River, and 0.283 m^3/s (10 cfs) along Mosquito Creek, and higher flows during drought operations (see Table 6). As such, the extensions will not be subject to new Highwood River Instream Objectives (IO) or Water Conservation Objectives (WCO). Water use under these licences is capped by the original licensed allocation. Generally licenses with July cut-off dates were issued more recently than the full season licenses and they have a lower priority than full season licenses. The licensees will be required to apply for amendments to their licenses for the extensions.

5.1.3 Assumes priorities for water use in keeping with legal requirements, within model limitations.

Priorities listed below are those used in the Scenario IDP8CS1 model run. Priorities 1 to 7 pertain to pre-Little Bow Project licensed projects and operating procedures. For the most part, they reflect statutory requirements and policy directives, but there are some exceptions that are made for modeling expediency (**Priorities** sidebar – page 31). Exceptions are noted in the list below. Priorities 8 to 15 are for future (Little Bow Project and post-Little Bow Project) conditions. They are intended to be implemented through licensing priorities (e.g. WCOs), conditions on licenses and policy directives.

- **Priority 1)** Pre-project Highwood, Little Bow and Mosquito Creek non-irrigation (see Characteristic 5.1.4).

- **Priority 2)** Pre-project Highwood irrigation.

- **Priority 3)** 1994 Highwood Diversions Operating Guidelines (see Characteristic 5.1.5).

- **Priority 4)** Pre-project Little Bow and Mosquito Creek irrigation without cut-offs.

- **Priority 5)** Pre-project Little Bow and Mosquito Creek irrigation, formerly with July cut-offs. July cut-offs assumed to be removed (see Characteristic 5.1.2).

- **Priority 6)** Minimum operating flow targets for Little Bow River and Mosquito Creek (see Characteristic 5.1.7).
- **Priority 7)** Target inflow (0.566 m^3/s or 20 cfs, April 1 to October 1) to Travers Reservoir.
- **Priority 8)** Pre-project Little Bow irrigation on and below Twin Valley Reservoir, formerly with July cut-offs. July cut-offs are assumed to be removed. Water use after the cut-off date is subject to minimum instream flow targets.
- **Priority 9)** Highwood River instream requirements as defined by Rule #3 (Figure 8) with built-in Drought Operations Plan.
- **Priority 10)** Target environmental flows for Upper Little Bow (1.133 m^3/s or 40 cfs) and Mosquito Creek upstream of Clear Lake Diversion (0.850 m^3/s or 30 cfs), April 1 to September 30.
- **Priority 11)** Clear Lake irrigation expansion. Clear Lake expansion was given priority over Lower Little Bow expansion because it has licensing priority.
- **Priority 12)** Lower Little Bow expansion.
- **Priority 13)** Clear Lake Wetlands.
- **Priority 14)** Clear Lake storage.
- **Priority 15)** Twin Valley Reservoir storage.

5.1.4 Uses include estimated weekly non-irrigation demand.

Non-irrigation demand includes municipal water use, industrial water use, water conservation projects, recreation projects and agricultural projects other than irrigation, such as feedlots. Demands reflect the year 2001 level of population and development, and are considered to be average demands (reflecting average weather conditions and an average weekly distribution). Demands are constant year-to-year.

5.1.5 Recognizes 1994 Highwood River Operating Guidelines as part of meeting Base Case conditions.

The 1994 Guidelines evolved over several years to regulate diversions from the Highwood River to the Little Bow River Basin. Their intended purpose was to meet demands in the Little Bow River Basin while, at the same time, protecting Highwood River instream conditions and avoiding fish kills. The guidelines include a table of values indicating how much water can be diverted at low natural flow conditions. The allowable diversions are modified when water temperature and dissolved oxygen conditions pose a threat to the Highwood River fishery. In brief, the 1994 Guidelines specify that:

1) The Women's Coulee and Little Bow Diversions will divert up to 4.5310 m^3/s (160 cfs) to meet domestic and licenced municipal, irrigation and industrial uses.
2) Total diversions will not exceed 60% of the Highwood River natural flow.
3) Diversions for irrigation in the Little Bow River Basin will not reduce Highwood River flows to less than 1.982 m^3/s (70 cfs).
4) Diversions for irrigation are subject to temperature and dissolved oxygen conditions on the Highwood River at Aldersyde.

5.1.6 Uses include estimated irrigation demands with license allocation cap.

Weekly farm gate irrigation demands for each irrigation block were estimated by Alberta Agriculture, Food and Rural Development based on the irrigated area, the mix of crops grown, the on-farm irrigation equipment used (efficiency), weather conditions (precipitation and evapo-transpiration), and on-farm irrigation management practices typical of those within irrigation districts with similar agro-climatic conditions. Irrigation demands are highly variable from year to year, being lower in cool, wet years and higher in hot, dry years. Demands are somewhat variable from sub-basin to sub-basin, increasing from northwest to southeast. Modelling assumed that irrigation applications ceased when the full licensed allocation was withdrawn from the source of supply, even if crop requirements are not fully met.

Irrigation demands for Clear Lake and Lower Little Bow expansion are based on crop types expected to be grown and on-farm equipment efficiencies largely based on low-pressure center pivot systems.

5.1.7 Defines minimum operating flow targets for Little Bow River and Mosquito Creek.

Minimum operating flow targets are base flows required to meet conveyance losses, keep the stream live to meet needs for traditional agricultural uses and other non-irrigation uses, and assist in maintaining water quality. Assumed minimum operating flow targets for the Little Bow River and Mosquito Creek are given in Table 6. The minimum operating flow targets (Priority 6) are subject to the 1994 Guidelines (Priority 3). When the temperature and dissolved oxygen conditions in the 1994 Guidelines come into play, the diversion to Women's Coulee will be reduced to zero, and the diversion to the Little Bow River will be reduced to 0.566 m^3/s (20 cfs). Flows in Women's Coulee and Mosquito Creek will depend on releases from storage in Women's Coulee Reservoir.

5.1.8 Defines Highwood River instream objective with drought operations plan.

The Highwood River instream requirement in Scenario IDP8CS1 is a variation of the instream flow needs (IFN) recommended by the Highwood Instream Flow Needs Technical Working Group (Figure 8). The adjustment from the recommended Highwood IFN to the Highwood Instream Objective Rule #3 (IO Rule #3) was made to reduce Lower Little Bow and Clear Lake irrigation expansion deficits. The adjustment encroached on the recommended IFN during high flow periods, but did not impact fish habitat during low flow periods.

The Drought Operations Plan is triggered under severe drought conditions to provide increased minimum operating flows to the Twin Valley Reservoir (2.124 m^3/s or 75 cfs in the Upper Little Bow River) and to Clear Lake (0.850 m^3/s or 30 cfs in Mosquito Creek upstream of the Clear Lake Diversion) for the period May 1 to July 15. The minimum flow targets are increased to divert more water into storage to avert back-to-back irrigation deficits greater than 100 mm. Drought operating procedures are triggered by a combination of a low water supply forecast and low reservoir levels. In Scenario IDP8CS1, drought procedures are called for in 10 of the 68 years for Clear Lake, and in four years for the Twin Valley Reservoir.

5.1.9 Sustains Clear Lake wetlands.

Between September 15 and October 31 each year when water is available, water is diverted to the wetlands to replace summer evaporation and restore FSL. If insufficient water is available in the fall, the wetlands are filled in spring, along with filling of Clear Lake.

5.1.10 Defines storage drawdown levels.

Both Clear Lake and the Twin Valley Reservoirs have minimum drawdown levels to protect the fishery, water quality and/or recreational interests.

5.2 Key Performance Findings

The modeling simulations and assessments indicate that the Scenario IDP8CS1 meets the objectives of the Highwood Diversion Plan /Little Bow Project to the extent possible without negatively impacting pre-project water users and existing Highwood fishery conditions, and without new storage development. Inherent in the recommendation to use Scenario IDP8CS1 as the basis for development of the Highwood Diversion Plan are trade-offs and value judgments.

Performance of Scenario IDP8CS1 in meeting the objectives established by the Joint Review Panel for the Highwood Diversion Plan is summarized in Table 7 and below as follows.

Objective: Ensure existing consumptive license commitments are upheld. Performance on existing licensed projects is as good or slightly better than that under pre-Little Bow Project conditions. The scenario modelling, however cannot show deficits experienced by individual licenses. Each sub-basin may have numerous water license projects in each block. Deficits are displayed as though they are shared equally among all licenses in each block. In actual operation and enforcement, this is not the case. Deficits impact irrigation and non-irrigation licensed water users sequentially in order of lowest priority to highest priority. It should be noted that deficits will continue to be experienced in Upper Little Bow and Mosquito Creek sub-basins due to the Highwood River temperature and dissolved oxygen criteria in the 1994 Guidelines. These shortages could not be accurately modeled with the weekly time step used in the simulation model.

Table 7 Objectives and performance summary for Scenario IDP8CS1.

Objectives	MET	NOT MET	UNCERTAIN
1. Uphold existing licence commitments	X		
2. Meet science-based IFN		X	
3. Provide ULB* and MC conveyance flows	X		
4. Preserve ULB and MC water quality			X
5. Meet Known future demands			
a) Irrigation Expansion (LLB and Clear Lake)	X		
b) Irrigation Lic. Applications (ULB and MC)		X	
c) Non-irrigation	Partially		
6. Sustain or improve over Base Case conditions for:			
a) Consumptive users	X		
b) Highwood fish habitat/aquatic ecosystem	X		
c) Highwood water quality	X		
d) ULB and MC water quality			X

Objective: Ensure that a science-based IFN is observed.
Based on the performance metrics developed by the Highwood Instream Flow Needs Technical Working Group, the proposed IDP does not provide significant improvement over the Base Case. Scenario IDP8CS1 falls short of meeting the recommended technical IFN largely because of statutory commitments of pre-Little Bow Project licenses (Objective 1).

The revised technical Highwood IFN calls for substantially more water than the Fish Rule Curve-based approach originally proposed by the proponent and reviewed in public hearings held by the Joint Review

Panel. While Scenario IDP8CS1 fails to meet the technical IFN, the modeling shows that IDP8CS1 provides significant improvement in fish habitat over that of the Fish Rule Curve approach.

Objective: Ensure that adequate conveyance flows are maintained in Upper Little Bow and Lower Mosquito Creek.
The minimum operating flow targets in IDP8CS1 are lower than the range of flows suggested by the Joint Review Panel. Any increase in the targets will further encroach on the Highwood River recommended technical Highwood River IFN. Water quality and riparian health in the Upper Little Bow and Mosquito Creek remains a concern. Monitoring is required to determine the impact of the new flow regime on these instream aquatic environments as well as on the water quality of the two storages, Twin Valley and Clear Lake Reservoirs, linked to these streams.

Objective: Ensure known future demands can be met.
Modeling was conducted assuming deficits would be shared equally among all Twin Valley Reservoir and Clear Lake expansion irrigators, primarily because of modeling limitations. With that assumption, under Scenario IDP8CS1, the committed 20,000 acres of irrigation expansion can be supplied with only occasional deficits. If deficits are not shared equally among all expansion irrigators, the burden of deficits falls on the most junior licensed projects. Each licensee would have to make a decision on his own risk and vulnerability, and whether or not expansion is in his best interests.

Objective: Reserve water for future requirements.
Some additional non-irrigation water use can supplied if the additional use can be accommodated within existing licenses. Any new or ongoing developments requiring new licenses that are subject to the recommended Highwood River IFN will face frequent and large deficits.

6.0 Analysis of Specific Issues

During the course of developing scenarios and assessing model results, a number of specific issues arose that required further analyses. The findings of these analyses helped to shape scenario development and final recommendations of the PAC.

The method of analysis involved running two scenarios with the only difference between them being the parameter being tested. The effect of the variation in the tested parameter is reflected in model results.

Specific issues addressed are discussed below.

6.1 July Cut-offs on Irrigation Licences

- **Issue:** What assumptions related to July cut-offs on pre-Little Bow Project irrigation licences should be used for the Base Case? What assumptions should be used for development of the Highwood Diversion Plan?

- **Background:** Under pre-project real time operations, irrigation licensees with July cut-offs were often granted extensions if sufficient water was available, and if minimum operating flow targets for the Little Bow River and Mosquito Creek could be met. The Base Case scenario is intended to represent pre-project conditions and be used as a basis for comparison in analyzing performance of post-project scenarios. The issue relates to what assumption regarding the cut-offs best reflects real time pre-project operations.

- **Analysis:** Scenario BC 2.1 assumed that the July irrigation cut-offs were enforced every year; BC2.2 assumed that the cut-offs would be extended or removed so that, if water was available, the full allocation could be met (if necessary to meet the crop requirement). The frequency of deficits greater than 50 mm for the two scenarios are shown on Figure 17.

  For Scenario 2.1, modeling output indicated that there would be deficits greater than 50 mm in 60 to 90 percent of the years for the cut-off irrigation projects. For Scenario BC2.2, deficits were reduced to between 5 and 15 percent of the years. Deficits were highest in the Lower Mosquito Creek Sub-basin. The magnitude and distribution of deficits for Lower Mosquito Creek Sub-basin are shown on Figure 18.

  Note that removing the cut-offs did not increase the frequency of deficits greater than 50 mm in the full season irrigation projects.

- **Conclusions:** Following discussions with irrigators and Alberta Environment administrators, it was concluded that Scenario BC2.2 was more representative of pre-project conditions than Scenario BC2.1. Scenario BC2.2 was adopted as the Base Case.

  Under post-project conditions, if cut-offs were not extended, irrigation deficits in the Upper Little Bow and Mosquito Creek Sub-basins would be much higher than they were under pre-project operating conditions, which is a condition that the PAC sought to avoid. If the cut-offs were extended, but subject to the new technical Highwood IFN, or some variation of it, irrigation deficits would exceed those experienced under actual pre-project operations, again an unacceptable situation. It was therefore decided that, in all future scenarios, removal of the cut-offs would be assumed, subject to the 1994 Guidelines and minimum operating flow targets.

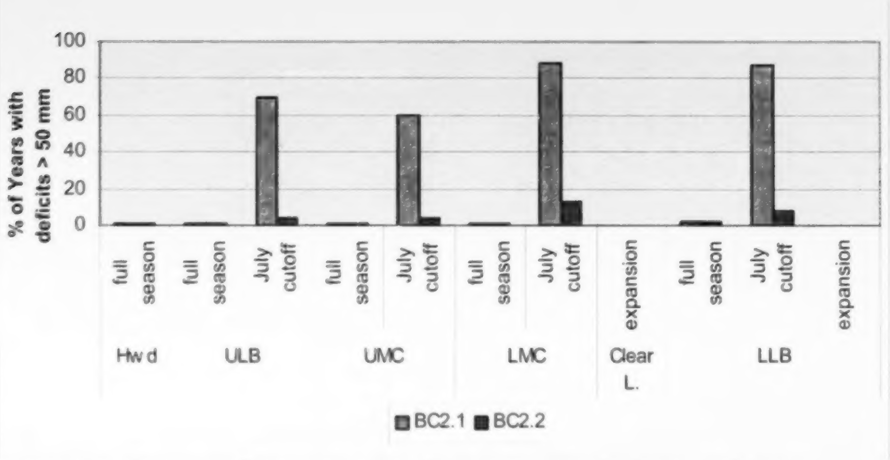


Figure 17 Impact of irrigation cut-off extensions on irrigation deficits.

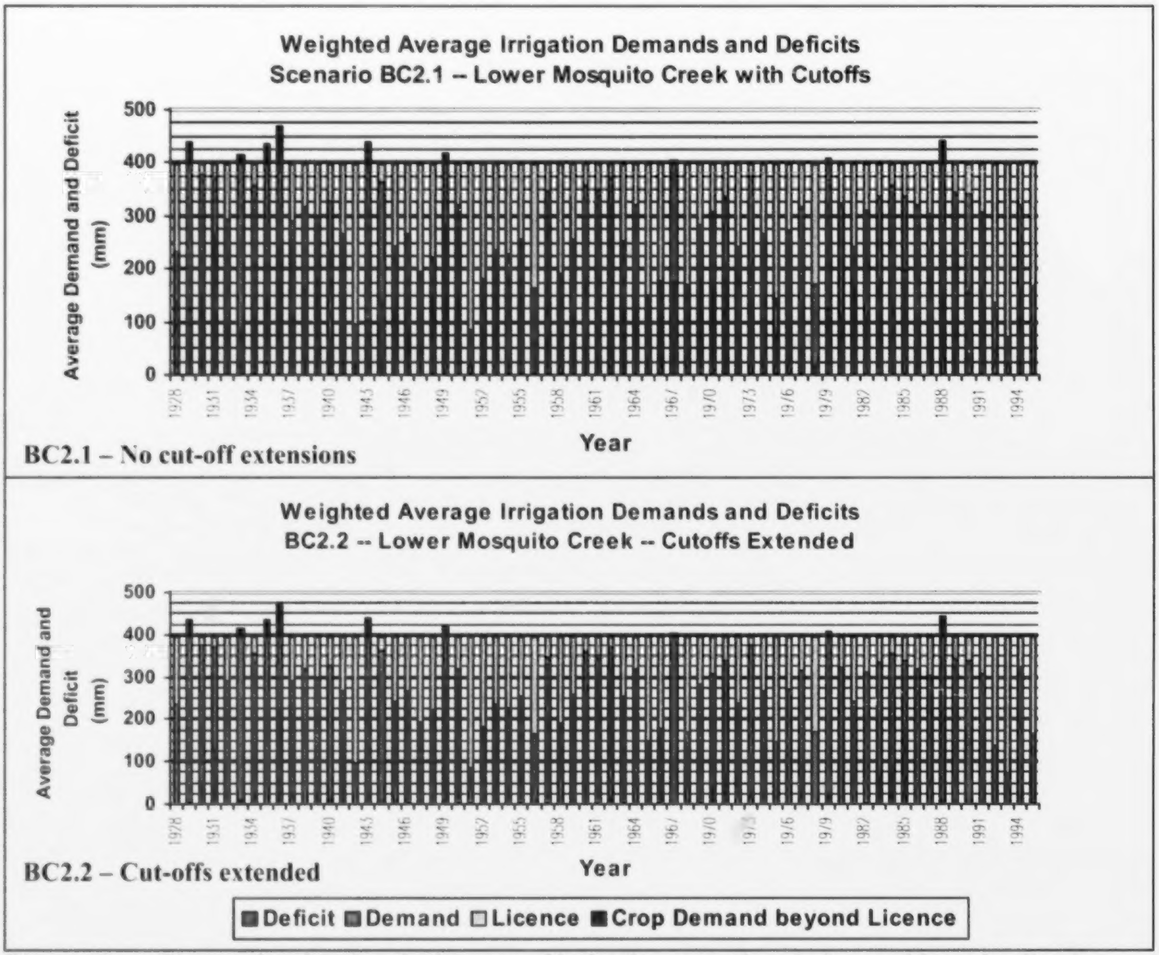


Figure 18 Time series showing the impacts of irrigation extensions in Lower Mosquito Creek Sub-basin.

6.2 Water Allocations versus Crop Irrigation Requirements

- **Issue:** What is the relationship between estimated crop irrigation requirements and licence allocation? What are the implications of ceasing irrigation withdrawals when the full allocation has been withdrawn?

- **Background:** In some irrigation blocks within the study area, the estimated water requirements for near-optimal yields of crops now irrigated greatly exceed the licence allocation. This is most evident in the Upper Little Bow and Mosquito Creek Sub-basin, where there is a high percentage of alfalfa, a high water demand crop, in the crop mix for full-season irrigation projects (Figure 19). Modelling assumes that irrigation ceases when the full allocation has been reached, even though the crops may require additional water to realize optimal yields.

  Figure 19 shows the relationship between weighted mean allocation and the 10, 50 and 90 percentile crop irrigation requirement (farm gate requirement, or withdrawal from the source stream). The figure indicates that ceasing irrigation when the full allocation is reached would not meet crop requirements in almost 50 percent of the years in the Upper Little Bow Sub-basin, and in about 75 percent of the years in the Mosquito Creek Sub-basin. This would result in reduced yields and revenues in the affected blocks.

Irrigation demands are variable from year to year, depending on weather. They are often expressed in percentiles. Ten percentile irrigation demands are cool, wet year demands that are met or exceeded in 90 percent of the years. Fifty percentile or median demands are met or exceeded in half of the years. Ninety percentile demands are hot, dry year demands met or exceeded in only 10 percent of the years. In recent years, AENV has set allocations for irrigation district licences at the 90-percentile demand level. With this allocation, irrigators would have the right to apply water to their crops in hot, dry years when irrigation is most needed and most beneficial.

- **Analysis:** Figure 20 shows the frequency of irrigation deficits for the Base Case (Scenario BC2.2) expressed in terms of:
  - **a)** the crop irrigation requirements or licence allocation, whichever is less, or
  - **b)** the crop irrigation requirements.

  For the full season blocks in Upper Little Bow and Mosquito Creek Sub-basins (in particular), there are frequent crop irrigation deficits greater than 50 mm even when there are few or no deficits to the full licence allocation.

- **Conclusions:** Continue to model assuming irrigation withdrawals cease when the full allocation has been reached. Continue to report deficits based on licence allocation or crop irrigation requirement, whichever is less. Draw the matter to the attention of licence holders.

6.3 Inactive Licensed Projects

- **Issue:** What would be the impact on irrigation deficits if all licensed irrigation projects were active?

- **Background:** Between 20 and 30 licensed projects in the study area were inactive during the late 1990s and early 2000s (pre-project), particularly in the Highwood River Basin where almost a third of the licensed projects were inactive. The Base Case scenario (BC2.2) assumed that only the irrigation projects that were active in 2001 were operating. This assumption best represents pre-project conditions.

Inactive licences could be reactivated at any time. If the licences are in "good standing" and other conditions are met, they could be transferred to a new user who could then begin using water. For these reasons, the IDP scenarios assumed that all licensed projects were active.

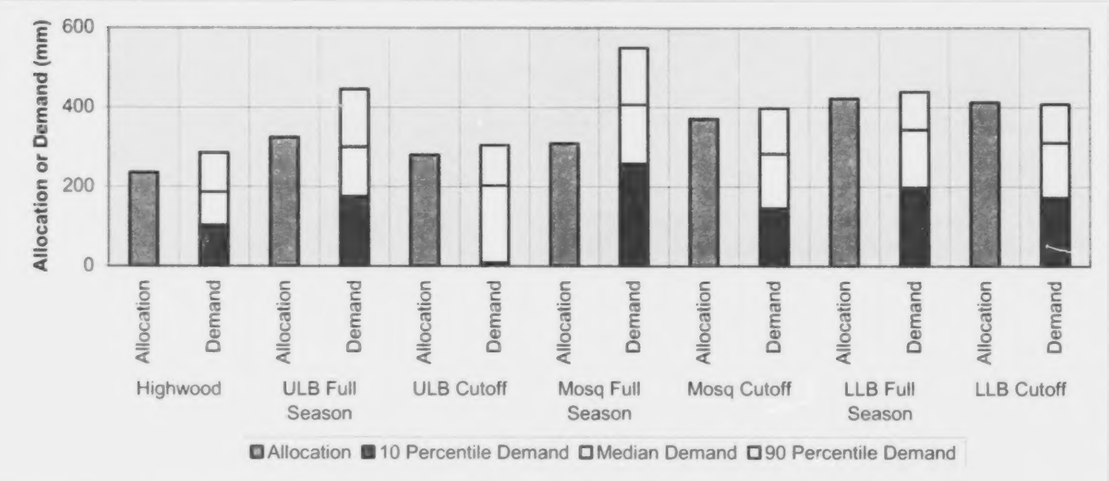


Figure 19 Relationships between licence allocation and crop irrigation requirement.

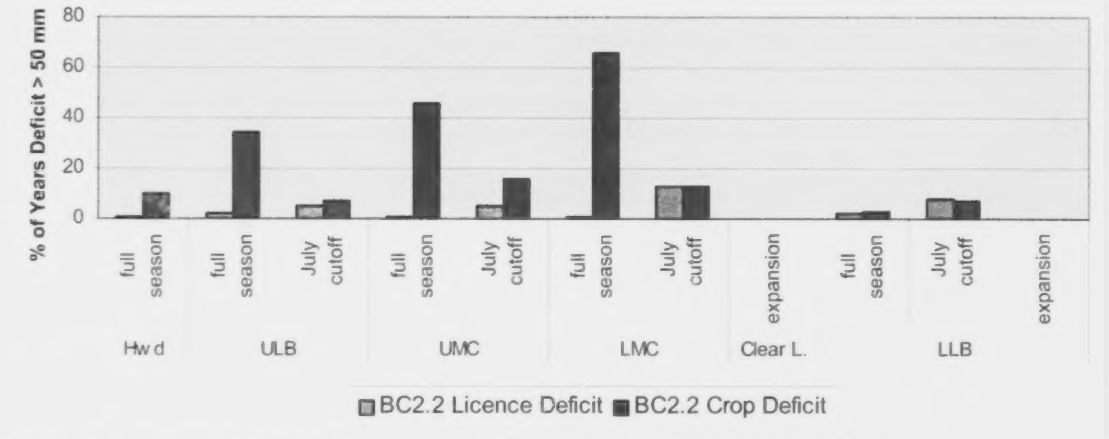


Figure 20 Modelled licence allocation deficit versus irrigation deficit for BC2.2.

- **Analysis:** An IDP scenario was run assuming only irrigation projects active in 2001 were operating to determine the impact on irrigation deficits. Model results showed no significant change in meeting irrigation demands in the Clear Lake and Lower Little Bow irrigation expansion blocks. Although there were a large number of inactive projects in 2001, they tended to be the smaller projects, and many of them were along the Highwood River downstream of the Little Bow Diversion.

- **Conclusion:** Assuming all licensed irrigation projects in the study area are active is a rational approach for developing the Highwood Diversion Plan. In any event, the assumption does not have a significant affect on irrigation performance. Canceling licences that have not been used for a period of time and for which there is no intention for use would remove the uncertainty related to inactive projects. Licences should be cancelled only where justified and after due process.

6.4 Impact of Temperature and Dissolved Oxygen Criteria in Operating Guidelines

- **Issue:** What impact do the temperature and dissolved oxygen criteria in the 1994 Highwood River Diversion Operating Guidelines ('94 Guidelines) have on irrigation deficits?

- **Background:** Temperature criteria were added to the Highwood River Diversion Guidelines in 1986, and dissolved oxygen criteria were added in 1990 (Fact Sheet, **Historical Review of Moratoria and Diversion Rules for the Highwood/Little Bow System** (Hart 2004; Compendium)). It was the understanding of at least some of the Little Bow water users that their acceptance of temperature and oxygen criteria in the Highwood Diversion Guidelines was on condition that they would be only temporary constraints until measures were in place to alleviate water deficits. From time to time, the validity and effectiveness of the temperature and oxygen criteria have been questioned. Some water users question whether the resulting fish habitat improvements justified the negative impacts on water users and water quality in the Little Bow River Basin. More information is required on the temperature and dissolved oxygen criteria, including the impact on consumptive use deficits in the Little Bow River Basin.

- **Analysis:** The Base Case scenario (BC2.2) included temperature and oxygen criteria in the operating guidelines. To determine the impact under pre-project conditions, Scenario BC2.2.2 was run assuming no temperature and oxygen conditions. Model output showed that the frequency of deficits greater than 50 mm was significantly greater for Scenario BC2.2 (with T and DO constraints) than for Scenario BC2.2.2 (without T and DO constraints), particularly in the Lower Mosquito Creek Sub-basin (Figures 21 and 22). In that sub-basin, the frequency of deficits greater than 50 mm decreased from 13 percent of the years to six percent of the years when the constraints were removed.

  To determine the impact under post-project conditions, model output for Scenario IDP2.5.2.3 (with T and DO constraints) was compared with Scenario IDP2.5.2.8 (without T and DO constraints). There were no significant reductions in the frequency of deficits greater than 50 mm when the constraints were removed.

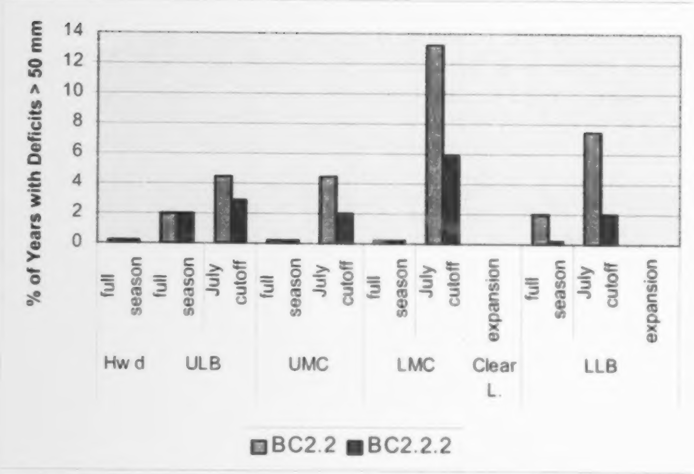
  The foregoing findings are tempered by the fact that the model works on a weekly time step. Temperature and dissolved oxygen irrigation shutdowns are implemented on an hourly basis. Real time impacts may be more frequent than indicated by modeling.

- **Conclusion:** Additional monitoring and analyses are required to determine the validity and effectiveness of temperature and dissolved oxygen criteria in the '94 Guidelines.

6.5 Impact of Increasing Non-irrigation Water Demands

- **Issue:** What is the impact of increased non-irrigation demands on performance of the project? What performance can non-irrigation users expect in meeting future needs?

- **Background:** Among other things, the EIA Joint Review Panel asked that the revised Highwood Diversion Plan be capable of meeting known future demands, and, if possible, water should be reserved for future demands that are unknown at the time. Future water demands are dependent on numerous variables that are difficult to predict. Human and livestock population growths, economic circumstances, technology, climate change and several other variables all affect future water demand. Future water demands were projected and scenarios were run to determine the impact of these new demands on the performance of the project, and the success of the project in meeting these new demands.



BC2.2 includes T and DO criteria; BC2.2.2 excludes T and DO criteria.

Figure 21 Impact of temperature and oxygen criteria on irrigation deficits under pre-project conditions.

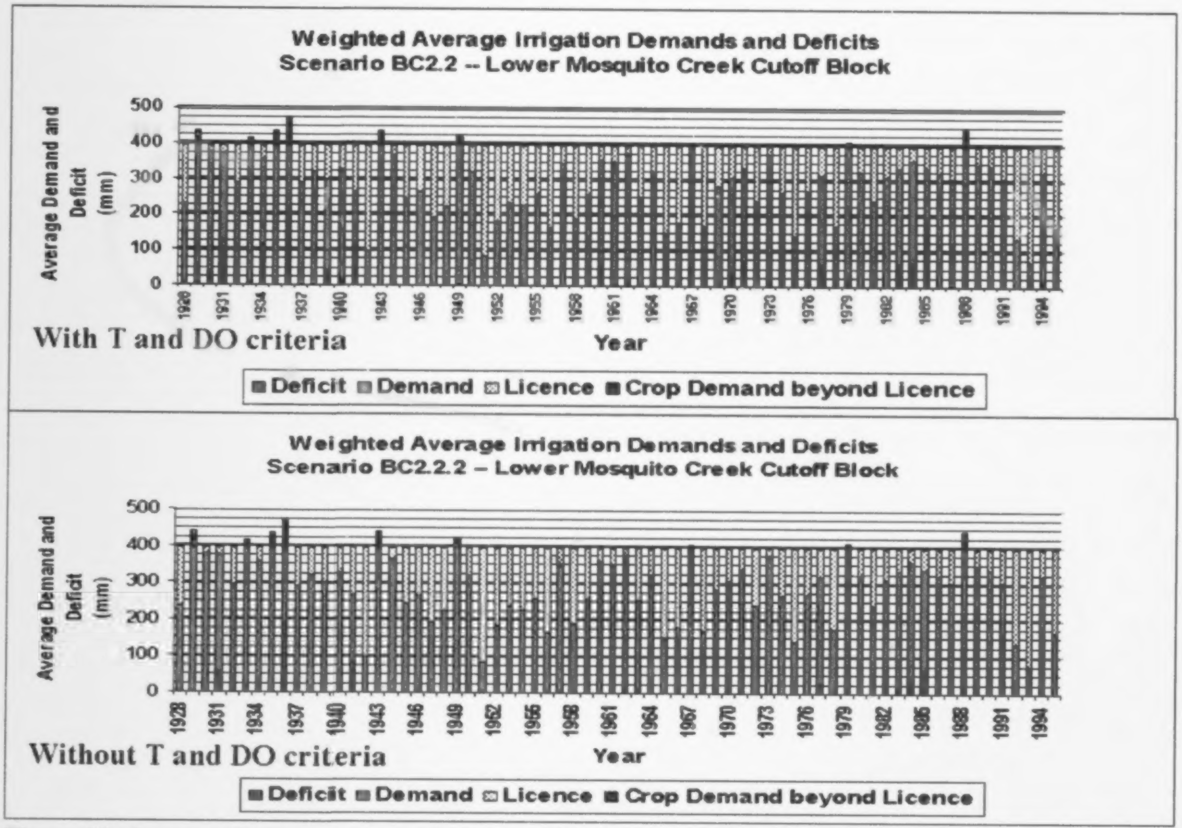


Figure 22 Impact of temperature and oxygen criteria on irrigation deficits under pre-project conditions in the Lower Mosquito Creek cut-off block.

- **Analysis:** Non-irrigation water requirements were projected to the 2021 level of demand based on population growth projections (human and livestock), a projected level of economic activity (Technical Note, **Future Water Demand Projections** (Hart 2004; Compendium)). Non-irrigation demands included municipal, rural domestic, livestock, industrial and recreation. Water conservation measures were assumed to be in place.

  Two scenarios were run to determine the impact of increasing non-irrigation uses to the projected 2021 level of demand:

  1) Scenario IDP2.5.2.9.8 – Year 2001 level of demand, including 20,000 acres of irrigation expansion associated with the project.

  2) Scenario IDP2.5.2.9.9 – Year 2021 level of non-irrigation demand. Irrigation demand remains the same as in Scenario IDP2.5.2.9.8.

  Model output showed no significant impact on performance for the irrigation expansion blocks, which are modeled as the lowest priority users for the 2001 level of demand. Model output showed that the performance in meeting future water uses would be good for uses that could be accommodated within existing pre-project licences. Performance would be very poor for new uses that would require new licences that would have a lower priority than the irrigation expansion associated with the project, and be subject to a new Highwood instream flow requirement such as Rule 3 (Figure 8).

- **Conclusions:** The proposed Highwood Diversion Plan would only partially meet the objective of having the capability to meet future demands. It would be successful only to the extent that future demands could be accommodated within existing pre-project licences.

  Licensing new projects downstream of the Twin Valley Reservoir should consider both irrigation and non-irrigation applications, in keeping with the priority system within the *Water Act*. New water right applicants for any purpose should be made aware of the risk of water supply deficits (magnitude and frequency) that could reasonably be expected. Applicants so informed should be given the opportunity to withdraw their application, modify their project or proceed with the project as per their application.

7.0 Public Input on Draft Recommendations of the Public Advisory Committee

Numerous scenarios were developed and evaluated in an effort to find the best balance between water consumption (e.g. municipal, industry, irrigation, livestock) and environmental protection (e.g. fish habitat, water quality, riparian habitat) while staying within current water regulations. The scenario that was judged to be the best compromise basis for developing the Highwood Diversion Plan was Scenario IDP8CS1. The Public Advisory Committee (PAC) prepared draft recommendations identifying Scenario IDP8CS1 as the basis for developing the Highwood Diversion Plan. The PAC also recommended inherent measures required for implementing the plan and verifying its performance. Several general draft recommendations that the PAC believed would improve water management in the study area are also included in this section of the report. These latter recommendations came to light in the course of work on the Highwood Diversion Plan and are not considered to be all-inclusive.

The draft recommendations of the PAC are included in this report as Appendix C.

The PAC held five "open house" public meetings to facilitate public review of their draft recommendations for the diversion and storage of water in the Highwood and Little Bow River Basins, and to provide the opportunity for input. The open house meetings were held in October and December, 2004. The Equus Consulting Group was contracted to provide advice to the PAC regarding the conduct of open house meetings, and to independently assess the public consultation process and the public input received.

Equus (2005; Compendium) reported that 81 participants at the five open houses completed a response form. Of the 81 responses received:

- 94 percent supported the objectives of the PAC (none were opposed).
- 92 percent were satisfied that the PAC was making appropriate recommendations (one disagreed).
- 83 percent indicated that the information received was clear or very clear.
- 87 percent indicated that they received the right amount of information at the open house meetings.
- 92 percent indicated that the PAC were helpful and open-minded at the meetings.

In addition, the PAC asked for opinions regarding the future allocation of water in the Highwood and Little Bow River Basins.

- 33 percent preferred closure of the basins to further licence allocations.
- 31 percent preferred limiting future allocation to only non-irrigation uses (the question may have been misinterpreted by some participants).
- 19 percent preferred continuing to allocate for any purpose.
- 17 percent did not express an opinion.

Equus concluded that responses received indicated that the public was highly satisfied with the efforts of the PAC to provide clear and sufficient information to open house participants. There was a high level of approval for the work of the PAC and the recommendations they have made. The participants indicated that they wanted the recommendations to be implemented as quickly as possible.

Equus noted six concerns raised by the public that should be addressed by the PAC and Alberta Environment. Each of the six concerns are listed below, followed by PAC comments in italics. The PAC recommendations referred to in the responses are those presented to the public (Chapter 6).

- There was some frustration that the process has taken a long time.

  PAC members and provincial government staff working on the project share the feeling that the process has been lengthy. Reasons for the delay in getting to the recommendations stage include the following.

  - *Technical studies, such as, Highwood IFN requirements, water quality modeling, and economics, have proven to be complex and time consuming.*
  - *Simulation modeling was the key analytical tool used in the study. It took considerable time to configure the model to accurately represent the Highwood/Little Bow system, review the databases, calibrate the model and familiarize PAC members with the concept, strengths and limitations of modeling and evaluating the output.*
  - *The PAC was committed to a thorough analysis of all issues related to the diversion plan recognizing the project's history, its complexity, and due process. Due process was largely established by the NRCB/CEAA Joint Review Panel. The intent was to arrive at rational, defendable recommendations that will withstand public, Alberta Environment and Joint Review Panel scrutiny. Judging by the input received at the public open houses, there is strong public support for the process that was followed and the recommendations arrived at by the PAC.*

- Implementation of the recommendations must be monitored and reported, possibly by a multi-stakeholder committee. Some participants suggested that the PAC should take on this role. Some noted the need for clear public information during implementation.

  The PAC fully agrees with this comment. Recommendation 1.5 calls for a core group of the current PAC to oversee implementation of the recommendations and performance monitoring, among other things.

- Some participants would like to see additional recommendations to address erosion and pollution concerns in the watershed.

  Erosion *– There will be short-term geomorphological changes, particularly along the Upper Little Bow River, as the channel shape and size adjusts to the new flow regime. After the adjustment period, which may take five to ten years, it is predicted that conditions will be favorable for establishing and maintaining healthy riparian vegetative communities, which will help to reduce erosion and stabilize the channel. The PAC has recommended that changes in channel characteristics and riparian vegetation be monitored and operational changes and land use practices that would hasten establishment of healthy riparian environments be identified and implemented (Recommendation 1.2c).*

  There is also an issue related to the erosion and turbidity caused by short-term fluctuations of diversions due to the temperature criteria in the 1994 Highwood River Operating Guidelines. This is particularly a concern in multi-day triggering of the temperature constraints and resulting operational changes as occurred in 2003. Fortunately, multi-day temperature constraints do not occur very often. The PAC has recommended that AENV undertake monitoring and analyses to determine the appropriateness and effectiveness of temperature and oxygen criteria in the 1994 Guidelines, and to determine if current operational practices being used to meet these guidelines are resulting in sufficient improvement in fishery conditions to justify the negative impacts on water users in the Little Bow River Basin (Recommendation 1.2b).

***Water Quality** – The PAC acknowledges that our database and analytical tools for addressing water quality issues are lacking. Efforts to develop reliable water quality simulation models were unsuccessful. Due to a lack of data, technical and professional judgement was used to set the minimum operating flow targets for the Upper Little Bow River (30 cfs) or for Mosquito Creek (10 cfs). Hence, the PAC has recommended an adaptive management approach (performance monitoring and adjustment) to addressing water quality issues (Recommendation 1.2 and 1.2a).*

It has been proposed that non-point pollution sources (land use practices) be identified and addressed in Phase II of the Highwood Management Plan. AENV and local watershed groups have carried out some preliminary work in this regard.

- Some participants were concerned that applications-in-progress may require special consideration, since expectations have changed during the several years of analyses and discussions.

  Licensing is the responsibility of Alberta Environment (AENV). AENV is aware that many of the applications were made 15 to 20 years ago, and that the agricultural industry has changed significantly since that time. In some cases land ownership has changed. This is similar to a situation that AENV has dealt with before (backlog of applications on Willow Creek). The PAC is confident that AENV will approach licensing in an appropriate manner.

  PAC Recommendation 4.0 calls for AENV to consider applications for all purposes (rather than solely for irrigation) for water use from Twin Valley Reservoir and downstream. Applications should be processed in the order that they were received. The total amount of water allocated should not exceed the amount required for the irrigation of 16,500 acres. A moratorium similar to the one currently in place (exempting some uses), and subject to instream objectives and flow targets should be put in place on the Highwood River, Upper Little Bow River and Mosquito Creek until Water Conservation Objectives have been established. It is further recommended that new water right applicants be made aware of the risk of water supply deficits that can reasonably be expected.

- A few participants felt that the rationale for rejecting water storage as part of future water management was either not clear or not convincing.

  There were very strong feelings about an enlarged Women's Coulee Reservoir. Most open house participants strongly supported PAC Recommendation 1.0 that the enlarged reservoir not be developed for the purposes intended (improving aquatic ecology of the Highwood River and meeting future consumptive water needs), pending further field studies and review of the Highwood instream flow requirements recommended by the Technical Working Group. The PAC felt that the enlarged reservoir was very costly in terms of economics, social disruption and impact on environmental and heritage resources – much too costly for the minimal benefit derived from the storage, as shown on Figure 16 (page 65). The reason that storage is less effective than expected is largely related to the new approach the Province has taken to defining instream flow requirements, an approach that has been used throughout the South Saskatchewan River Basin.

  A few open house participants were disappointed that an enlarged Women's Coulee Reservoir was not more effective in meeting its intended purposes. Some felt that either offstream or onstream storage was needed somewhere in the basin to regulate flows and accommodate future uses. The PAC feels that verification of the instream flow requirements and evaluation of the basin fishery is a prerequisite to further consideration of storage.

- The question on future allocation priorities produced ambiguous results. The PAC should provide a clear rationale for its recommendation in this area. Some PAC members felt there may have been some confusion by what was implied by the three options presented.

The PAC expected a wide range of responses related to this question. The PAC feels that the validity of the Highwood River technical IFN and Water Conservation Objectives for the entire study area need to be addressed before definitive recommendations on future allocation priorities can be considered (Recommendation 7.0). In the meantime, the PAC recommends that,

- *licensing proceed for all purposes, for applications from Twin Valley Reservoir and downstream, for a total allocation up to the amount of water required for the irrigation of 16,500 acres;*
- *a moratorium similar to the one currently in place (exempting some uses), and subject to instream objectives and flow targets should be put in place for the Highwood River Basin, and the Upper Little Bow and Mosquito Creek Sub-basins; and*
- *applicants should be informed of risks of water supply deficits that can reasonably be expected prior to licences being issued (Recommendation 4.0).*

Fisheries and Oceans Canada (DFO) Concerns

In September 2004, DFO came forward with written comments on the preferred scenario, IDP8CS1. They indicated that, on average, the Scenario IDP8CS1 flow regime looks good. Highwood River flows are higher than Base Case flows in a large number of weeks, and, on average, for the entire study period. However, in many weeks Scenario IDP8SC1 Highwood River flows are less than Base Case flows. Scenario IDPCS1 frequently shows reduced habitat over the Base Case scenario at all discharges. Spring and late summer are the most impacted periods. DFO asserted that habitat losses in one period could not be offset by habitat gains in another period. "Fish must live in the flow of the moment."

A meeting was held in December 2004 to further explore DFO's concerns, and to identify possible solutions. It was decided to test a modified operating plan that would delay increasing the minimum operating flow target for the Upper Little Bow from 0.566 m^3/s to 0.850 m^3/s (from 20 cfs to 30 cfs) by two weeks each spring, and to hasten decreasing the flow target from 0.850 m^3/s to 0.566 m^3/s (from 30 cfs to 20 cfs) by two weeks in the fall. In addition, the drought operations would come into effect two weeks later for both Little Bow and Women's Coulee Diversions. Diversions during droughts would be increased somewhat to avoid severe deficits to consumptive users. The resulting scenario was referred to as IDP8CS3.

The results of Scenario IDP8CS3 were forwarded to DFO for evaluation. In a letter dated April 26, 2005, DFO indicated their satisfaction with Scenario IDP8CS3, by stating that it "will not likely result in the harmful alteration, disruption or destruction (HADD) of fish habitat over that in the currently authorized Base Case."

The results of Scenario IDP8CS3 were discussed with representatives of the irrigation industry in June 2005. Irrigation deficits in the new scenario were somewhat increased over those of Scenario IDP8CS1, the scenario recommended by the PAC to form the basis of the Highwood Diversion Plan. The irrigation representatives felt that they could not support a scenario that increased the risk to producers over the risks that they accepted in Scenario IDP8CS1. They suggested that adjustments be made to reduce the risks to equal or less than that of Scenario IDP8CS1.

A new scenario was developed by amending operations during drought years to reduce irrigation deficits to approximately equal those of Scenario IDP8CS1. The minimum operating flow targets were slightly increased in the mid-May to mid-July period during drought years. The new scenario was labeled IDP8CS5. DFO evaluated the output from Scenario IDP8CS5. They indicated that performance was poorer for the new scenario than for Scenario IDP8CS3 in the mid-May to mid-July period. Scenario IDP8CS5 would probably trigger a HADD under Section 35(2) of the *Fisheries Act*.

The PAC Management Sub-committee concluded that there is very little flexibility in the Highwood/Little Bow system; changes made to improve performance for one objective would negatively impact another objective. One additional scenario was tested, the objective being to achieve Scenario IDP8CS3 fish habitat performance and Scenario IDP8SC1 irrigation performance. This was accomplished by reducing the irrigation expansion in the Lower Little Bow Sub-basin from 6680 ha to 6146 ha (from 16,500 acres to 15,180 acres; an eight percent reduction from the target expansion). This scenario was labeled IDP8CS3R92.

The Management Sub-committee decided to present all new scenarios to the PAC for discussion, and work toward a consensus on the scenario to recommend as a basis for the Highwood Diversion Plan.

The PAC meeting was held on November 9, 2005. The results and implications for four scenarios (CS1, CS3, CS5 and CS3R92) were presented and discussed. By consensus, it was decided to go forward with a recommendation that the Highwood Diversion Plan be based on Scenario IDP8CS1, as agreed at the PAC meeting in September 2004. Rationale for the decision was as follows:

- There was very little difference in performance among the four scenarios using the same performance parameters and criteria used to evaluate performance for all scenarios (Table 4).
- Irrigation representatives felt that they could not accept more risk than they had with Scenario IDP8CS1.
- Upper Little Bow water quality would be a concern, particularly in the fall, with any of the operation plans that were modified to address DFO concerns.
- The Little Bow Project was justified based on an additional 6680 ha (16,500 ac) of irrigation expansion. Reducing the irrigated area is unacceptable.
- DFO were late in providing their input. It was not received until after arrangements for public meetings were made and materials prepared. Changing key recommendation now would probably require a new round of public consultations.

8.0 Final Recommendations of the Public Advisory Committee

Public input at the five open houses held in October and December 2004 indicated a high level of approval for the work of the PAC and the recommendations that they have made. The PAC made no changes to the recommendations as a result of input received from the public other than some clarifications and editorial changes.

The following changes were made to the draft recommendations, primarily to clarify certain aspects.

- **Numbering System** – The primary PAC recommendation relates to the Highwood Diversion Plan (Recommendation 1.0). Recommendations that relate to implementing the Highwood Diversion Plan (HDP) and performance monitoring are numbered as a subset of Recommendation 1.0 (Recommendations 1.1 to 1.5). Additional recommendations that came to light in the course of developing the HDP are numbered Recommendations 1.0 to 8.0 in the draft recommendations. For report purposes, the complete set of recommendations are numbered sequentially as Recommendations 1.0 to 9.0. This eliminated two Recommendation 1.0s in the draft set of recommendations.

- **Editorial Corrections and Clarifications** – Changes related to sentence structure, terminology and typographical errors. The intents of the recommendations were not changed.

- **Water Conservation Objectives, Moratoria and the Need for a Comprehensive Fishery Study** In the draft recommendations, water conservation objectives, moratoria and the need for a fisheries study in the Highwood River Basin were discussed in several locations. In the final recommendations, all discussions are consolidated in Recommendation 8.0.

Recommendations

1.0 Highwood Diversion Plan Without Additional Storage

It is recommended the Highwood Diversion Plan be developed based on the attributes of Scenario IDP8CS1, which does not include additional storage in Highwood basin. Details of the storage assessment are found in the Fact Sheet: Review of Additional Storage (Middleton 2004; Compendium). The key attributes, priorities and performance of Scenario IDP8CS1 are outlined in Chapter 5.0 of this report. An Alberta Environment operations report (draft) on the proposed Highwood Diversion Plan (HDP), based on Scenario IDP8CS1, is available as a separate document.

The Public Advisory Committee determined that the proposed HDP meets the objectives of the Highwood/Little Bow Project to the extent possible without negatively impacting pre-project water users, including the lower Highwood River fishery, and without additional storage development. The additional storage development investigated (Super Expanded Women's Coulee Reservoir) did not result in sufficiently improved performance of Scenario IDP8CS1 to justify its high cost and its social and environmental disruption.

Contingent measures or strategies for implementing and operating the Highwood Diversion Plan are essential and inseparable from the diversion plan itself. These are as follows.

1.1 Irrigation Licences with July Cut-offs

It is recommended pre-Little Bow Project irrigation licensees holding licences with July cut-offs be given a two-year opportunity to apply for removal of the cut-off by licence amendment.

In actual operation of the Highwood/Little Bow system, the irrigation licensees with July cut-offs were often granted extensions to continue irrigation after the cut-off date when the 1994 Guidelines for Highwood River Diversion and minimum operating flow targets on the Little Bow River and Mosquito Creek could be met. Scenario IDP8CS1 recognizes this water management practice by removing the cut-off date, subject to the 1994 Guidelines and to minimum operating flow targets of 0.850 m^3/s (30 cfs) along the Upper Little Bow River, 0.566 m^3/s (20 cfs) along the Lower Little Bow River, and 0.283 m^3/s (10 cfs) along Mosquito Creek. The modelling showed that irrigation performance improved over pre-project performance for these licences, and that pre-project protection of the Highwood River fishery was maintained. In addition, making post-cut-off date irrigation withdrawals subject to minimum operating flow targets would alleviate the potential for instream flows in the Little Bow Basin being drawn down to near zero in late summer.

It is recommended that licensees be given the opportunity to permanently remove the cut-off date, subject to the instream conditions. There would be no change in the licence allocation or change in the priority and administration of the licences for water use prior to the cut-off date. To simplify administration and operations, it is recommended that those licensees who choose not to apply for removal of the cut-off not have their cut-offs extended in future years, regardless of the water supply situation in the Highwood and Little Bow Basins.

It is recommended that notice of this window of opportunity be forwarded to the licensees, along with application forms for amendments. It is suggested that a reminder be sent out to those licensees who had not submitted an application within one year of the first notice.

1.2 Performance Monitoring for Adaptive Management

It is recommended that a monitoring program and performance assessment strategy be developed and implemented to evaluate the effectiveness of the Highwood Diversion Plan in achieving the water management objectives and to provide a basis for adaptive management of the system.

Commitments to completing the monitoring programs and providing timely interpretations must be adhered to and carried out in consultation with a core group of the Phase 1 HWMP-PAC to assure timely, responsible and accountable adaptive management decisions. The monitoring agency should report to the core group on a regular basis, at least annually, on the status of the monitoring program and future plans.

The PAC's work required updating the water demand and supply databases to establish performance criteria for the existing diversion operations (Base Case). This task was made difficult and often thwarted by information gaps resulting from incomplete or outdated monitoring programs. Where monitoring programs were done, documentation of results was often incomplete or lacking.

The new proposed diversion plan will impose flow regime changes along the streams. Accurately predicting the response of the complex ecosystems in the Highwood and Little Bow River Basins to these changes is clearly beyond the capability of the Public Advisory Committee and its advisors. As well, the reliability of the real operation of this plan to meet water management objectives defined in the modelled scenario has yet to be performance tested. This led to the PAC adopting the concept of adaptive management. Adaptive management requires an ability to identify and monitor parameters affecting performance, and to respond to unsatisfactory performance with corrective actions.

Systematic monitoring and assessments will enable validation of the operation guidelines, or identification of areas where operational refinements are required to minimize negative impacts on the environment and the consumptive users. Performance monitoring and assessment is recommended in the areas of water quality, riparian habitat, Highwood fishery criteria, and water use, as noted in Recommendations 1.2a to 1.2d.

Simulation modeling has shown that there is very little flexibility in the operation of the Highwood diversion structures. The differences in flows among the scenarios tested are small. A key issue is the relationship between fish habitat in the lower Highwood River, and water quality in the Upper Little Bow River and Mosquito Creek. The Joint Review Panel recommended a minimum flow of 0.85 to 1.13 m^3/s (30 to 40 cubic feet per second) during the operating season. Preliminary water quality analyses suggest that at least 0.85 m^3/s (30 cfs) was required to maintain adequate water quality to protect fish in the Upper Little Bow River. A minimum flow of only 0.57 m^3/s (20 cfs) is currently being used in the preliminary operating plan. Questions related to this issue include:

- What is the minimum flow required to protect water quality in the Upper Little Bow River and Mosquito Creek, and for what period during the operating season?
- Does a difference of 0.28 to 0.57 m^3/s (10 to 20 cfs) in diversions from the Highwood River significantly affect fish movement or habitat in the Highwood River?
- Efforts to fine-tune the recommended scenario led to the testing of several scenarios that showed little difference in the flows diverted to the Little Bow River Basin and the flows remaining in the Highwood River. Small changes in flows can have significant water quality benefits in the Upper Little Bow and Mosquito Creek. Do the differences in Highwood River flows among various scenarios significantly affect water quality, fish movements, fish habitat and fish populations in the Highwood River?

Development of a performance-monitoring program will require:

- Identification and co-ordination of existing monitoring programs to identify deficiencies.
- Establishing monitoring purpose, protocols and parameters (e.g. locations, timing, frequency and durations of monitoring, analytical techniques, etc.).
- Establishing the agencies and work units responsible for the monitoring and assessment.
- Preparing and reviewing interpretation reports of monitoring results on a timely basis.
- Advising the project operators and the public advisory committee(s) of findings and suggestions for operational changes.

1.2a Water Quality Monitoring

It is recommended that AENV review existing water quality monitoring in the Highwood and Little Bow River Basins by all parties (Provincial and Federal Governments, industry, communities, rural municipalities, Ducks Unlimited, Trout Unlimited, etc), and develop a comprehensive, co-coordinated plan to provide a database for addressing a number of issues, including:

- **Frank Lake water quality impacts on the Little Bow River and Twin Valley Reservoir.**
- **Upper Little Bow water quality for maintenance of the aquatic ecosystem and protection of municipal, domestic, stock water, and irrigation water supplies.**
- **Mosquito Creek water quality for the protection of municipal, domestic, stock water, and irrigation water supplies. The new flow regime has significantly increased turbidity in Mosquito Creek.**

- **Determining the water quality suitability of the Twin Valley and Clear Lake Reservoirs for their respective multi-purpose uses (e.g. recreation, irrigation, source for raw drinking water, fishery).**
- **Highwood River water quality for maintenance of the aquatic ecosystem and protection of municipal, domestic, stock water, industrial and irrigation water supplies.**

Water quality monitoring requirements must be specified in detail and tied to specific objectives. Monitoring must be coordinated and efficient. Completing the monitoring program and providing timely interpretations are required.

1.2b Highwood River Fishery Water Temperature and Dissolved Oxygen Operating Criteria

It is recommended that AENV undertake monitoring and analyses to determine the appropriateness and effectiveness of the temperature and oxygen criteria in the 1994 Highwood River Diversion Guidelines and associated operating and monitoring procedures. It is recommended that an assessment be carried out to determine whether or not changes in the diversions triggered by the temperature and dissolved oxygen criteria have had the desired impact on Highwood River water quality.

Temperature criteria were added to Highwood River Diversion Guidelines in 1986, and dissolved oxygen criteria were added in 1990. It was the understanding of some of the Little Bow water users that acceptance of temperature and oxygen criteria in the Highwood Diversion Guidelines was on condition that they would only be temporary constraints until measures were in place to alleviate water deficits. In the 1997/1998 EIA Hearings conducted by the Joint Review Panel, there was considerable discussion of the validity of the temperature criteria, and whether or not the resulting improved fish habitat conditions justified the negative impacts on water users in the Little Bow River Basin. Analysis and discussion was hampered by a lack of data and concrete evidence that cutbacks in diversions significantly improved Highwood River temperature conditions. Furthermore, temperature driven operations of multi-day on-again, off-again diversion cutbacks cause significant operational problems for Little Bow basin water users, as well as negatively impacting water quality and the re-stabilization of riparian vegetation along the upper Little Bow River. Dissolved oxygen has not been a constraint since 1989 when treated effluent from the Town of High River was discharged to Frank Lake rather than to the Highwood River.

The validity and effectiveness of the temperature and dissolved oxygen constraints in the 1994 Highwood River Diversion Guidelines and the associated operating and monitoring procedures need to be re-examined.

1.2c Riparian Habitat

It is recommended efforts be made to operate the Little Bow Diversion works in a manner that fosters a healthy riparian environment along the Upper Little Bow River (Rood et al, 2002 and 2002A). It is recommended that AENV develop and implement a monitoring and management program that tracks geomorphologic and riparian vegetation changes along the Upper Little Bow River.

It is predicted there will be geomorphologic changes along the Upper Little Bow River as the channel size and shape adjusts to the new flow regime. Once equilibrium has been reached, it has been projected there could be significant improvement in the potential for establishing and maintaining riparian vegetation. However, these predictions are not certain.

A monitoring and management program would identify and evaluate changes that occur, recommend required refinements to the operating procedures for the diversion works, and identify land use practices that would assist in establishing and maintaining a healthy riparian ecosystem. This would improve prospects for optimizing riparian benefits of the new flow regime, and minimizing the negative impacts.

Riparian conditions along the Highwood River and Mosquito Creek are not expected to change significantly under post-project flow regimes. Riparian habitat improvement programs are underway in the study area. These programs should be continued, and expansion to other areas should be encouraged.

1.2d Water Use Monitoring and Reporting

It is recommended that AENV develop and implement a simple water use monitoring and reporting system to record the annual and seasonal variations in water uses and return flows in the Highwood and Little Bow River Basins. Improved monitoring and reporting is required to assist in planning, operations and enforcements.

Most licences require the water user record and report annual water use to AENV. These licence conditions have not been consistently enforced. The records that have been received by AENV have not been compiled and analyzed in recent years. Compiled, systematic water use records combined with adequate instream flow monitoring data would greatly assist in water management planning, operating the project and enforcement.

Many municipalities and industries currently record water use and return flow. For irrigation users, at a minimum, a simple time on/time off recording procedure and the pump rating would provide a valuable record. Water use return cards and clear instructions should be developed by AENV for the convenience of the user. On-line, electronic reporting is an option that should be considered.

1.3 Communications

It is recommended AENV work with the water users to develop a communications system to improve the operator's ability to match water deliveries with water demands and to reduce impacts of irregularities in diversion operations.

Monitoring and reporting should be supported by good communications between operators and water users, because operators do not have perfect knowledge of water supply or demand. Users should be kept informed of operations and be alerted to irregularities, or potential irregularities, through local contact people.

In an open channel system it is not possible to perfectly match water supply with water demands. However, good communications between operators and water users will help to minimize over-deliveries due to uncertainties in day-to-day water demands, and help to make more efficient use of the water supply. Irrigation districts in southern Alberta have worked out water ordering procedures that could possibly be adapted to improve operational efficiency in the Highwood/Little Bow system (Appendix B). It is believed that a similar system developed in consultation with the irrigators would improve the supply-demand efficiency of the diversion system. Electronic communications should be considered.

1.4 Enforcement

It is recommended AENV enforce the allocations, and terms and conditions of licences and temporary licences in the Highwood and Little Bow River Basins.

The modeling results indicated many irrigation projects are under-allocated for the types of crops now grown. The farm gate demand for the types of crops grown exceeds the licence allocation in many years. PAC recommendations are based on modelling results assuming diversions cease when the full allocation has been withdrawn from the source stream. Periodic, random water audits should be conducted to ensure users are not diverting in excess of their licence allocations.

AENV administrators should be receptive to, and encourage water rationing and deficit sharing in times of deficits rather than strict adherence to the priority system. However, in the absence of a sharing arrangement, the priority system should be enforced.

Issuing temporary licences and the use of such licences requires improved compliance scrutiny. No temporary diversions should have priority over licensed uses or instream minimum flow requirements except possibly for municipal emergency use.

1.5 Role of Core Advisory Body from the Phase I Public Advisory Committee

It is recommended that AENV recognize a role for, and establish as an entity, a core group of the current Public Advisory Committee for the following purposes:

- **Oversee the timely implementation of the recommendations presented herein. Progress reports, prepared by Alberta Environment, on each and every recommendation should be provided to the core group at least once a year.**
- **Report to the Phase II PAC on Highwood Diversion Plan performance monitoring.**
- **Act as a sounding board for AENV administrators to test various ideas and options for implementation.**
- **Provide continuity and input to AENV in the conduct of Phase II of the Highwood Management Plan.**
- **To work with the Phase II group on setting Water Conservation Objectives.**
- **Provide AENV with a point of contact for public notification of allocation transfer applications, licence and temporary licence applications, and other significant water management issues in the Highwood and Little Bow River Basins.**

The wealth of information and experience gained by the Phase 1 PAC over the past five years would be of great value in implementing the recommendations and continuing the planning program for the Highwood River/Little Bow Basins.

Recommendations considered by PAC to be important for future water management in the Highwood/Little basins are as follows.

2.0 New Storage Development

Simulation modeling showed that the Super Expanded Women's Coulee Reservoir would provide minimal benefits toward meeting the recommended technical instream flow needs (IFN) on the Highwood River. **It is recommended that development of the Super Expanded Women's Coulee storage site or any other similar major storage in the Highwood basin not be developed, pending further fishery field studies.**

The primary intended purpose of the Super Expanded Women's Coulee storage site would be to improve the aquatic ecology of the Highwood River. The storage performance study (Fact Sheet: **Review of Additional Storage** (Middleton 2004; Compendium)) shows no significant benefits to the Highwood River. The hydrology of the Highwood River and the new recommended technical IFN are such that there would be limited water available for diversion to storage without impinging on the IFN. In low runoff years, reservoir storage would be depleted and there would be no benefits when they are most needed.

Also, the social and environmental disruption and high cost of the project also do not justify this concept. Other storage sites investigated by Alberta Infrastructure and Transportation in the 2001 storage option study were even less attractive than the Super Expanded Women's Coulee site (Alberta Infrastructure and Transportation 2001).

PAC is concerned with the large increase in water required to meet the recommended technical Highwood IFN in a basin where periodic water shortages are known to occur. The recommended technical Highwood IFN calls for substantially more water than the Fish Rule Curve-based approach originally proposed by the proponent for the Little Bow Project and reviewed in public hearings held by the Joint Review Panel. The PAC strongly believes that before consideration is given to any storage in the Highwood Basin there is need for a comprehensive fishery field study on the whole Highwood system including its tributaries to determine the value of this fishery, and the validity of its aquatic habitat requirements and the recommended technical IFN (Recommendation 8.0).

3.0 Licence for the Pre-project Little Bow Diversion

It is recommended a licence for the pre-project 2.83 m^3/s (100 cfs) Little Bow Diversion be issued to the Crown in the Right of Alberta Environment.

In 1898 the Government of the Northwest Territories applied for a licence to divert 1.42 m^3/s (50 cfs) from the Highwood River in NE 1-19-29-4 to the Little Bow River for domestic purposes. These works were licensed in 1905. In 1922, the Little Bow Irrigation District applied for a licence to divert from the Highwood River in NW 6-19-28-4, sufficient water for irrigation of 1335 ha (3300 acres) in the Little Bow River Basin. An Authorization was issued in the same year. The Little Bow Irrigation District (LBID) entered into an agreement with the Crown in 1922 whereby the LBID would operate its works to deliver the 1.42 m^3/s (50 cfs) entitlement of the Crown under the August 1905 licence, plus the flow required to meet the needs of its irrigators (an additional 1.42 m^3/s or 50 cfs, approximately). The troublesome government works in NE 1-19-29-4 were abandoned. The 1905 licence was not transferred to the LBID and was cancelled in 1977.

The LBID experienced financial problems. In 1950 an Order-in-Council dissolved the LBID and transferred ownership and operation of the works Authorized in 1922 to the Crown. The Order-in-Council recognized that the works were intended to serve domestic and irrigation needs. The Crown made necessary repairs and improvements to the works and assumed responsibility for operations. At that time, the Crown was not bound by the *Water Resources Act*. (In 1971 the *Act* was amended to bind the Crown. Prior to this, it was assumed that no licence was required for Crown-owned works.) The pre-Little Bow Project capacity of the diversion works was 2.83 m^3/s (100 cfs). The 2.83 m^3/s (100 cfs) diversion remains unlicensed.

Licensing the 2.83 m^3/s (100 cfs) pre-project diversion would clarify ownership and the rights that exist as a result of Crown assuming responsibility for the pre-project diversion in 1922. Priorities would be ascertained. Licensing the 2.83 m^3/s (100 cfs) diversion would provide a mechanism for clarifying operation of the diversion works and providing legal status for the portion of Highwood Diversion Plan that applies to the pre-project works.

4.0 Legal status for the Highwood Diversion Plan

It is recommended the Highwood Diversion Plan be incorporated as an operation plan into Alberta Environment licences for the Women's Coulee and Little Bow Diversion works.

Incorporating the Highwood Diversion Plan into licences would give the plan legal status and a priority. Three licences would be involved: the Women's Coulee Diversion licence issued November 7, 1997, the Little Bow Diversion licence issued March 28, 2000, and a new licence proposed to be issued for the 2.83

m^3/s (100 cfs) pre-project Little Bow Diversion (Recommendation No. 3.0). Procedures for modifying the plan should be included as conditions on the licences. These conditions should be defined in consultation with the core group of the Phase 1 PAC. Modifications that significantly affect performance in meeting objectives should be subject to public review and appeal.

5.0 Licensing Post-Little Bow Project Water Use

It is recommended that AENV continue to license projects using water from, and downstream of, the Twin Valley Reservoir in accord with the application and priority system under the *Water Act*. Licensing should not be limited solely to irrigation; other uses to consider include municipal, industrial and other (non-irrigation) agricultural uses. Total allocations for all uses shall not exceed the amount of water required for the irrigation of 6677 ha (16,500 acres).

Moratoria, with exempted uses similar to the existing moratoria, should be established under the *Water Act* for the Highwood River, Upper Little Bow River and Mosquito Creek. The moratoria should clearly state that licences for exempted uses, including temporary licenses, should be subject to the instream objectives for the Highwood River and the minimum operating flow targets for the Little Bow River and Mosquito Creek, consistent with the recommended Highwood Diversion Plan. The moratoria may be rescinded when Water Conservation Objectives have been established (Recommendation 8.0).

If real-time operation of the HDP is to be performance assessed it is important that instream guidelines be recognized in allocating new licensing, including temporary licenses. The documentation on the existing moratoria is sparse and unclear on instream conditions for licences issued under the exemption clause. The existing moratoria should be revised to clarify instream requirements. It is recommended that, in the future, licensing new water right applicants for any purpose be made aware of the risk (magnitude and frequency) of water supply deficits that can reasonably be expected. Informed applicants should be given the opportunity to withdraw their application, modify their project or proceed with the project as per their application.

6.0 Cancellation of Inactive Licences

It is recommended AENV cancel water licences that have not been used for a period of at least three years, and where there is no reasonable prospect for exercising the rights granted under the licence. The water should not be reallocated.

Unused allocated water creates a condition of uncertainty in a basin. If administrators do not know if or when the project will be activated, planning for economic growth and environmental protection is compromised.

It is essential that cancellations be implemented only where justified, and only after due process. Cancellations will be subject to appeal by the licensee.

Stream reaches are defined as:

- Highwood River – The entire mainstem river.
- Upper Little Bow – The mainstem stream from the Little Bow Diversion headgate to the upstream end of Twin Valley Reservoir, taken as Coal Mine Road (SSW2-16-26-W4).
- Lower Little Bow – The reservoir and mainstem river from Coal Mine Road to the upstream end of Travers Reservoir.
- Mosquito Creek – Includes Women's Coulee from the diversion headgate to its confluence with Mosquito Creek, and Mosquito Creek from the Women's Coulee confluence to the Mosquito Creek arm of Twin Valley Reservoir.

7.0 Licence Allocation Transfers

It is recommended licence allocation transfers (entire or partial) of mainstem Highwood River, Mosquito Creek, or Little Bow River water be permitted only after review of factors listed in the *Water Act*, and under the following additional conditions:

- **The seller and buyer are on the mainstem streams in the same sub-basin or stream reach (Highwood River, Upper Little Bow, Lower Little Bow and Mosquito Creek). For example, if the seller's licence is on Mosquito Creek, the buyer's licence should also be on Mosquito Creek.**
- **There is no adverse impact on environmental quality or other water users on the affected stream reach.**
- **Downstream transfers within the same reach are preferred, however, some upstream transfers within the same reach may also be acceptable where they have minimal instream and consumptive impacts and they provide for beneficial use. Transferring allocations from downstream of the Twin Valley, Clear Lake or Women's Coulee Reservoirs to upstream of those reservoirs would not be acceptable.**
- **Transfers for like purposes would be preferred, however, a change of use purpose may be acceptable provided that the withdrawal period for the new licence is within the same withdrawal period for the original licence.**
- **A licence dependent upon stored water in Twin Valley, Clear Lake or Women's Coulee Reservoirs (including downstream projects) should only be transferred to a buyer who will be dependent on the same stored water. For instance, an allocation using water from Twin Valley Reservoir or downstream (Lower Little Bow reach) should not be transferred to a user upstream of the Twin Valley Reservoir (Upper Little Bow reach).**
- **Public input is always sought. To help facilitate public input, the core group of the Phase I PAC and all licence holders within the same reach should be advised of transfer applications by either AENV or by the applicant (as directed by AENV).**
- **Transfers that would increase post-HDP diversions from the Highwood River during drought conditions, when the Highwood Instream Objectives or Water Conservation Objectives are not being met, are unacceptable. Increased future diversions from the Highwood River beyond the diversions in Scenario IDP8CS1 during critical low flow periods would further encroach on the Highwood IO or WCO and should be avoided.**
- **Transfers to different water users should include a 10 percent holdback for the purpose of contributing to instream flow requirements. Transfers involving a licensee trying to improve efficiency of water use through relocation from one land location to a different but proximal land location owned by the same licensee should not include a holdback. Transfers of allocations that divert directly from a reservoir lake and that keep the new diversion point on the same reservoir should not include holdbacks as there is no instream benefit to be gained as along as the diversion remains on the reservoir.**

Water allocation transfers and holdbacks in the South Saskatchewan River Basin were approved in Phase I of the South Saskatchewan River Basin Water Management Plan (AENV 2002).

The primary objectives for permitting transfers in the Highwood/Little Bow study area are to provide an opportunity for new users or existing users requiring additional water to obtain a licence in these fully allocated basins, and to contribute to instream needs through holdbacks. It must be recognized that in the water-short streams of the Highwood/Little Bow River basins, a downstream licence allocation serves purposes beyond that of the licensee. A downstream allocation contributes to upstream flows, and improved water quality and riparian conditions. These benefits would continue if the transfers remain on the same mainstem reach. Downstream transfers within the same reach would enhance instream flow conditions and are therefore preferred. However, some upstream transfers within the same reach may also be acceptable. Transfers for like purposes would probably minimize impacts on the stream and other users, however, transfers for different purposes should not be ruled out where they have minimal instream and consumptive impacts, and provide benefits.

Allocations from a reservoir or downstream of a reservoir should not be transferred to a location that is upstream of storage.

8.0 Highwood River Water Conservation Objectives and Moratoria

It is recommended that establishing Water Conservation Objectives on the Highwood River, Upper Little Bow River and Mosquito Creek be further explored. In the meantime, it is recommended that moratoria, with exemptions similar to the existing moratoria, be established for these streams. The moratoria must ensure that licences for exempted uses, including approvals for temporary uses on these streams, are subject to the same instream objectives and minimum operating flow targets that are inherent in the proposed Highwood Diversion Plan.

The PAC supports the concept of Water Conservation Objectives for protection of the aquatic environment of the streams, and as receptacles for licence transfers and holdbacks. The PAC recognized the recommended technical IFN in its efforts toward developing Scenario IDP8CS1 as the basis for the Highwood Diversion Plan. Every effort was made to minimize encroachments on the recommended IFN while attempting to meet other objectives of the project. However, the PAC is concerned about the large increase in flow requirements called for by the new technical Highwood IFN. Assigning a WCO that meets this IFN could shut down the basin for further water licensing in a community that is under increasing development pressure.

Some fishery experts and the PAC question the validity of the IFN assessment for Highwood because of the lack of supportive observed fish and related aquatic habitat data on the Highwood system (Highwood IFN, Peer Review, 2001). The PAC feels that it cannot assign a WCO to the Highwood River until the technical Highwood IFN has been validated or revised, and a more comprehensive and integrated approach to establishing WCOs in the entire Highwood/Sheep/Little Bow system has been undertaken. It is further recommended IFN investigations be given a high priority in Phase II of the Highwood Management Plan Study. In the meantime, moratoria should be established under the *Water Act* for the Highwood River Basin, Upper Little Bow and Mosquito Creek. Licences for exempted uses, including approvals for temporary uses, should be subject to Highwood River instream objectives and Little Bow River and Mosquito Creek minimum operating flow targets defined in the Highwood Diversion Plan.

9.0 Highwood Management Plan – Phase II

It is recommended AENV proceed with Phase II of Highwood water management planning. The Phase II study should include, but not be limited to:

- **An integrated and validated instream flow requirement study of major streams and tributaries in the Highwood/Sheep/ Little Bow system to assist in the establishment of instream Water Conservation Objectives.**
- **Track monitoring assessments on Highwood Diversion Plan performance.**
- **Sheep River water supply and environmental issues.**
- **Groundwater issues and the relationships between surface water and near-by groundwater.**
- **Continue investigations into non-storage water management options.**

The issues identified are those that have been raised by the PAC in the course of conducting the Phase I study on the Highwood Diversion Plan. They are not intended to be all-inclusive.

References

Alberta Environment 1997. Little Bow Diversion summary document submitted to the Joint Review Panel for the Highwood/Little Bow Public Hearings. Alberta Environment. Lethbridge, AB.

Alberta Infrastructure and Transportation 2001. Highwood Basin Storage Study – Comparative Site Assessment. Alberta Infrastructure and Transportation. Edmonton, AB.

Alberta Environment, Undated. Framework for Water Management Planning. Alberta Environment. Edmonton, AB.

AMEC 2001. Non-storage Options Assessments; Highwood Management Plan Phase I. Alberta Environment. Calgary, AB.

AMEC 2002. Alternate Water Supply Sources for the Highwood River, Little Bow River and Mosquito Creek Basins. Letter Report dated May 6, 2002. Alberta Environment. Calgary, AB.

Anderson 2002. Highwood River Basin Water Management Planning. Draft report dated March 31, 2002. Alberta Environment. Calgary, AB.

Anderson 2003. Profile of Irrigation in the Highwood – Little Bow: Constraints and Opportunities. Draft report dated January 27, 2003. Alberta Environment. Calgary, AB.

Clipperton G. K, R. F. Courtney, T. S. Hardin, A. G. H. Locke, G. L. Waldner. 2002. Highwood River Instream Flow Needs. Alberta Infrastructure and Transportation. Edmonton, AB.

Cows and Fish Program. 2001. Community Report: An Inventory and Assessment of the Functioning Condition of Riparian Habitat for the Upper Little Bow River. Upper Little Bow River Water Users Association. High River, AB.

Cross, P.M. 1989. Instream Flow Requirements for Water Quality in the Highwood River. Planning Division, Alberta Environment. Calgary, AB

DFO 1998. Habitat Conservation and Protection Guidelines – Second Edition. Communications Directorate, Fisheries and Oceans Canada. Ottawa, ON.

Golder Associates Ltd. 2003. Highwood/Little Bow River Interim Diversion Plan: Water Quality Implications. Draft Report. Alberta Infrastructure and Transportation. Edmonton, AB.

Golder Associates Ltd. 2003A. Highwood River Habitat Evaluation Methods and Affected Reaches within the Context of the Highwood River Basin. Letter Report. April 25, 2003. Alberta Infrastructure and Transportation. Edmonton, AB.

Irrigation Water Management Study Committee 2002. Irrigation in the 21st Century: Volume 4 Modelling Irrigation Water Management. Alberta Agriculture, Food and Rural Development. Lethbridge, AB.

Irrigation Water Management Study Committee 2002A. Irrigation in the 21st Century: Summary Report (Executive Summary Page xvii). Alberta Agriculture, Food and Rural Development. Lethbridge, AB.

NRCB, CEAA 1998. Report of the NRCB/CEAA Joint Review Panel: Little Bow Project/Highwood Diversion Plan. NRCB. Edmonton, AB.

Rood S.B. 2002. Instream Flows and Riparian Vegetation along the Highwood and Little Bow Rivers and Mosquito Creek: Performance Assessment for Scenario Evaluation. Paper prepared for Civil Projects Branch, Alberta Infrastructure and Transportation. Edmonton, AB.

Rood S.B., G. Samuelson, D.G. Smith, W. Wilms. 2002A. Probable Impacts of Instream Flow Augmentation on Channel Processes and Riparian Vegetation along the Upper Little Bow River, Alberta. Civil Projects Branch, Alberta Infrastructure and Transportation. Edmonton, AB.

Sosiak A. and R. Hazewinkel. 2002. Flows Required to Protect Water Quality in the Little Bow River and Mosquito Creek. Science and Standards Division, Alberta Environment. Calgary, AB.
Sosiak, A. 2001. Predictive Equations for Suspended Solids and Dissolved Oxygen in the Highwood River. Science and Standards Division, Alberta Environment. Calgary, AB.

Taylor, B.R. and B.A. Barton. 1992. Temperature and Dissolved Oxygen Criteria for Alberta Fishes in Flowing Waters. Alberta Fish and Wildlife. Edmonton, AB.

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Appendix A: Relationship to Other Planning Initiatives

A description of the inter-relationships of a planning activity to other ongoing planning activities is a requirement specified in the Framework for Water Management Planning (Alberta Environment, Undated).

- **Water for Life: Alberta's Strategy for Sustainability**

Population growth, increasing agricultural and industrial water demands and recurring droughts have increased pressure on Alberta's water resources and the risk to the health and well-being of Albertans, the provincial economy and the aquatic ecosystems. Water for Life: Alberta's Strategy for Sustainability is Alberta's response to these issues. The objectives of Water for Life are to develop a new water management approach and outline specific strategies and actions to address three objectives:

- Safe, secure drinking water supplies.
- Healthy aquatic ecosystems.
- Reliable, good quality water supplies for a sustainable economy.

A set of core principles that have been used to guide the Water for Life program emerged from a public consultation process.

- Albertans must recognize that there are limits to the available water supply.
- Alberta's water resources must be managed within the capacity of individual watersheds.
- Citizens, communities, industry and government must share responsibility for water management and work together to improve conditions within their local watersheds.
- Knowledge of Alberta's water supply and quality is the foundation of effective decision-making.
- Albertans must become leaders at using water more effectively and efficiently.
- Alberta must preserve the "first-in-time, first-in-right principle for granting and administering water allocations. Allocation transfers ensure societal demands and needs can be met.
- Healthy aquatic ecosystems are vital to a high quality of life for Albertans, and must be preserved.
- Groundwater and surface water must be preserved in pursuing economic and community development.
- Alberta will continue to be a leader in drinking water quality and standards to ensure Albertans have safe, secure drinking water.

In March 2003, the province released draft recommendations on managing Alberta's water needs, maintaining the province's economic prosperity, and addressing environmental concerns. Following public consultations, in November 2003, a report outlining the province's short-term, medium-term and long-term strategies for sustainability was released. The province continues to work on implementing the strategies under oversight of the multi-stakeholder Provincial Water Advisory Council.

Additional information is available on the Water for Life website: www.waterforlife.gov.ab.ca.

The Highwood Water Management Plan and, more specifically, the Highwood Diversion Plan are regional initiatives dealing with unique and specific issues in the Highwood and Little Bow River Basins. The work on development of the Highwood Diversion Plan has proceeded parallel with, but independent of, work on the much broader Water for Life program. Generally, the work on the Highwood Diversion Plan and the recommendations of the Public Advisory Committee are in keeping with the core principles established in the Water for Life program. When the Water for Life strategies are implemented, there may be cause to revisit some of the PAC recommendations. Amendments to the recommendations, if any, will require public consultations.

- **South Saskatchewan River Basin Water Management Plan**

Alberta Environment is developing a water management plan to maximize the benefits of water use in the South Saskatchewan River Basin (SSRB) in a sustainable and environmentally responsible way. Led by a government steering committee, the plan involves input from four multi-sector stakeholder Basin Advisory Committees and the general public. The Basin Advisory Committees provide advice on water management in each of the four sub-basins – Red Deer River, Bow River, Oldman River and South Saskatchewan River (downstream of the Bow/Oldman Rivers confluence).

Phase 1 of the water management plan was approved in June 2002. It authorizes water allocation transfers within the SSRB, subject to Alberta Environment approval and conditions.

Phase 2 addressed water management issues, including the availability of water for future allocations and to maintain river flows for the aquatic environment. Phase 2 seeks to find the best balance between water consumption and environmental protection in the SSRB. This includes defining water conservation objectives (flows to remain in rivers) after consideration of economic and social values and ecological requirements. In July 2004, the Basin Advisory Committees submitted their recommendations for Phase 2 to Alberta Environment. The recommendations are currently being considered by the government steering committee.

More detailed information, including complete versions of reports, is available on Alberta Environment's website: www.gov.ab.ca/env/water/regions/ssrb.

The recommendations of the Public Advisory Committee related to the Highwood Diversion Plan and management of the Highwood and Little Bow River Basins are in keeping with the Phase 1 recommendations of the SSRB Water Management Plan. The Highwood Public Advisory Committee is aware of the work of the SSRB Basin Advisory Committees and the potential for conflict between Highwood Water Management Plan recommendations and SSRB Phase 2 recommendations. Concerns have been expressed about the potential for water conservation objectives for the Bow River affecting municipal water supplies and economic growth in the Highwood River Basin (regardless of what water conservation objectives are established for the Highwood River). Discussions may be required to resolve conflicts emanating from the two parallel planning initiatives. The urgency of water management issues in the Highwood/Little Bow study area was sufficient reason to proceed with parallel planning programs.

- **Bow River Basin Council**

The Bow River Basin Council (BRBC) is a multi-stakeholder, charitable organization dedicated to conducting activities for the improvement and protection of the waters of the Bow River Basin, considering:

  - Riparian zones.
  - Aquatic ecosystems.
  - Quality and quantity of water.
  - Effects of land use on surface and groundwater.

The Bow River Basin includes the Highwood and Sheep River Basins.

The BRBC activities include:

  - Participating on committees, and in workshops, conferences, water use management and planning activities related to the use, management and protection of Bow River Basin waters.

  - Developing and recommending improved water use management procedures and performance measures.

- Encouraging the implementation of cooperative water use management strategies.
- Participating in activities that promote and demonstrate increased awareness of water use management issues to its members, the governments of Alberta and Canada, and the public.

The BRBC is currently working on a state of the Bow River Basin report, an update of a similar initiative reported on in 1994. The purpose of the state of the basin reports is to establish "baseline" data that could form the basis for assessing future changes in the river, determining whether or not those changes were positive or negative, and initiating corrective actions where necessary.

The mandate and work of the BRBC is complementary the objectives of the Highwood Water Management Plan Public Advisory Committee. No conflicts with the Phase I recommendations are foreseen.

- **Oldman Watershed Council**

The Oldman Watershed Council (OWC) was formed in September 2004 as a successor to the Oldman Basin Advisory Council (BAC) that was established to provide basin input to the SSRB Water Management Plan.

The Council's mission is to maintain and improve the Oldman River watershed through partnerships, knowledge and the implementation and integration of sustainable water management and land use practices. The Oldman River watershed includes the Little Bow River Basin. The Council provides leadership and guidance in watershed planning and management, monitoring water quality, and promoting stewardship. The OWC assumed responsibility for the Oldman River Basin Water Quality Initiative. The OWC will not only carry on the work of the Initiative and the BAC, but will also act as the Oldman Watershed Planning and Advisory Council as part of the Water for Life Strategy.

The mission and work of the OWC is complementary the objectives of the Highwood Water Management Plan Public Advisory Committee. No conflicts with the Phase I recommendations are foreseen. The OWC may assist in implementing some of the recommendations.

- **Oldman River Basin Water Quality Initiative**

The Oldman River Basin Water Quality Initiative began in 1997 in response to serious concerns expressed in the community about protecting water quality in the Oldman River Basin. The Initiative's 1998-2002 Action Plan emphasized the importance of three types of activities to be carried out during that five-year period: collecting baseline information on water quality and how to improve it, classifying land use, and communicating the activities of the Initiative.

During the first four years, efforts focused on collecting data (water quality and land use), interpreting and analyzing it (exploring land use and water quality relationships on a basin scale), and pursuing work on beneficial management practices with an agricultural emphasis.

The emphasis of the Initiative during the next five years will shift toward understanding beneficial management practices and encouraging practice change. Equal priority will be given to rural and urban areas (towns, villages and cities) across the basin. The first component of this effort will involve two pilot areas (a storm sewer catchment area and an agricultural sub basin) where beneficial management practices will be applied, tested and refined. The second component will involve sharing results about successful practices and encouraging communities throughout the Basin to use them.

There are no foreseeable conflicts between the work being carried out under the Oldman River Basin Water Quality Initiative and the recommendations of the Highwood Water Management Plan Public Advisory Committee. Some of the recommendations of the PAC may be carried out under the Oldman River Basin Water Quality Initiative.

- **Cows and Fish**

The Alberta Cows and Fish program was established in 1992 through a partnership between the Alberta Beef Producers; Trout Unlimited Canada; the Canadian Cattlemen's Association; Alberta Sustainable Resource Development; Alberta Environment; Alberta Agriculture, Food and Rural Development; Prairie Farm Rehabilitation Administration; Fisheries and Oceans Canada; and Alberta Conservation Association. The mission of Cows and Fish is to promote the improvement of riparian areas, and their ecological processes and functions, through a collaborative partnerships and voluntary, proactive community-based actions that use education and awareness about management options for livestock producers and their communities. The Cows and Fish partners are working together with farm and ranch families to foster a better understanding of how improvements in grazing management on riparian areas can enhance landscape health and productivity, for the benefit of producers and others who use and value riparian areas.

In collaboration with the Cows and Fish program, a number of community groups and individuals in the Highwood and Little Bow River Basins are actively working on implementing sound grazing management practices and riparian vegetation restoration and management. These include:

- Municipal District of Ranchland
- Upper Little Bow Basin Water Users Association
- Lower Mosquito Creek Water Users Association
- Tongue Creek Ranch - Hartell, Alberta
- OH Ranch - Longview, Alberta
- Glen & Kelly Hall - Stavely, Alberta
- The Pekisko Group
- Middle Little Bow River Watershed Group
- Full Circle Adventures (Sheep River)

The work of these groups is complimentary to the objectives of the Highwood Water Management Plan and the recommendations of the PAC. Their work should be supported.

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Phase I: Highwood Diversion Plan

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Highwood Water Management Plan: Phase 1 Terms of Reference

(Alberta Environment October 2000)

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Highwood Management Plan - Phase 1
Terms of Reference

1. Background

The need for a Highwood River Basin Water Management Plan was identified during the Highwood Instream Flow Needs process. In January 1991, the Highwood IFN Technical Subcommittee made their approval of a preliminary IFN and consensus on project operations contingent on the completion of a Highwood River Basin Water Management Plan that would address a variety of water management issues in the Highwood River Basin.

The Natural Resources Conservation Board (NRCB) Decision Report of May 1998 deferred approval of an expansion to the storage capacity of the Women's Coulee (formerly Squaw Coulee) Reservoir and of the Highwood River Diversion Plan during the low flow season of late July and August. The NRCB issued a Board Order requiring the Operator to:

a. submit further information regarding a super expanded Women's Coulee Reservoir;
b. provide an updated comparative analysis of potential storage sites within the Highwood River Basin;
c. revise the Highwood IFN analysis; and
d. provide an updated plan for the completion of the Highwood River Basin Water Management Plan, now referred to as the Highwood Management Plan (HMP).

The activities required to provide the above information are very closely related to activities that would occur during the HMP. This document describes the approach that Alberta Environment proposes for ensuring a clear and logical relationship between the Board Order work and the HMP.

2. Approach to Developing the Highwood Management Plan

At public meetings held in High River, in the spring of 1999, many stakeholders expressed interest in having the HMP proceed before Alberta Infrastructure and Alberta Environment respond to the Board Order conditions. A main concern expressed was that the NRCB be presented with a range of options for solving water management problems.

Components of the HMP that directly affect the development of a revised Highwood River Diversion Plan or the assessment of potential storage sites would be completed as Phase 1 of the HMP. Phase 1 would be completed during the investigations being undertaken to satisfy the requirements of the Board Order. Remaining HMP activities can occur in Phase 2.

The HMP will be closely linked with the current public process for the Board Order. In order to maintain progress and make use of available resources, those aspects of the HMP that are not essential to Board Order items, would be deferred to Phase 2 and would be undertaken some time after the Operator makes a complete submission to the NRCB. An example of a deferred aspect would be the establishment of instream objectives for tributary streams unaffected by the

Little Bow Project/Highwood Diversion Plan. The timing of Phase 2 would depend on overall provincial water management priorities and budget allocations.

3. Geographical Area

The Highwood Management Plan will include the Highwood River Basin, the upper Little Bow River Basin, and the lower Mosquito Creek Basin (including the Women's Coulee system). [p. 4-56, Decision Report]

4. Scope of the Highwood Management Plan

The following sections describe HMP products and the issues that would be considered in the development of these products:

a. Phase 1 - Focus on tasks related to the information needs of the NRCB, including the development of a Diversion Plan from the Highwood River and a comprehensive assessment of storage options.

b. Phase 2 - Remaining HMP tasks.

4.1. Phase 1

1. Products

The purpose of Phase 1 is to provide information for consideration by Alberta Environment in developing a water management plan consistent with the requirements of the *Water Act*. Products will include:

a. a proposed **Highwood Diversion Plan** that considers recommendations from a Public Advisory Committee (PAC) and assumes various levels of available storage until site-specific data are available. (If public consensus is not forthcoming, **a small set of alternatives** for a Highwood Diversion Plan will be provided, incorporating computer-based water management simulations and processed output. Each alternative would be accompanied by a statement from both supporters and dissenters.).

b. recommended **instream objective(s)** for the Highwood River between the Women's Coulee Diversion and the confluence with the Sheep River;

c. a recommended process for how items outside the essential Phase 1 components of the HMP would be dealt with in Phase 2. These items comprise the components of the plan that do not bear on the immediate needs of the Little Bow Project/Highwood Diversion Plan; and

d. a report documenting the Phase 1 contribution to the HMP and a recommended process for Phase 2.

2. Approach:

Balanced and representative public consultation with an independent mediated/facilitated process [pp. C-4, 4-56, Decision Report].

3. Issues to be addressed:

a. examination of significant future development in the Highwood and Little Bow Basins and associated growth and demand for water [p. 4-56, Decision Report];

b. examination of non-storage options, including:
    - acceptable level of deficits;
    - water transfers;
    - water conservation; and
    - voluntary licence buy-backs (Alberta Environment will not support proposals that involve the expropriation of water licences.).

c. revised instream flow needs for the Highwood River [pp. C-3, Decision Report];

d. examination of fisheries management considerations, including instream flow needs for fish habitat in the Highwood River during the winter and the need for habitat improvement [p. 4-56, Decision Report];

e. consideration of flood protection and planning in the Highwood Basin [p. 4-56, Decision Report];

f. a diversion plan for the Highwood River and a plan for development of additional storage (including small storage for domestic and stockwatering) that meet three criteria for sustainability:
    - respect statutory rights to water for household purposes, rights for traditional agricultural uses and existing water licences and not cause the loss of, or injury to, existing water rights [developed from p. 4-1, Decision Report];
    - meet basic environmental criteria to avoid significant adverse effects [p. 4-1, Decision Report]; and
    - meet current and future needs for water for domestic, riparian, and municipal needs, and other consumptive uses [p. 4-1, Decision Report].

g. consideration of the role of the Highwood River Basin in the context of the Bow River Basin [p. 4-56, Decision Report];

h. examination of all sources of pollutants including non-point agricultural sources [p. 4-56, Decision Report] (This item is understood by Alberta Environment to focus primarily on the Little Bow Basin.);

i. re-examination of the need for instream flow needs for Mosquito Creek and the upper Little Bow River [p. 4-56, Decision Report];

j. Frank Lake Water Quality Mitigation Plan [p. B-7, Decision Report];

k. Little Bow River Reservoir Water Quality Protection Plan [p. B-7, Decision Report]; and
  - plan to address livestock effects on riparian habitat and water quality in the Little Bow Basin. [p. B-7, Decision Report] (insofar as it is a part of the Little Bow River Reservoir Water Quality Plan)

l. assessment of the feasibility and desirability of managing fisheries upstream of the Little Bow River Reservoir in the Little Bow River for cool-water species, taking into consideration the role of the diversion works on the Highwood River, diversion canal, and implications of flow fluctuations for cool-water species [p. B-4, Decision Report].

4.2. Phase 2

1. Depending on further assessment of needs and available resources, the HMP may eventually include:

   a. instream objectives for the Sheep River;

   b. instream objectives for other significant streams (e.g., Threepoint Creek, Ware Creek, Pekisko Creek, Stimson Creek);

   c. (as specified in the *Water Act*) matters or factors that must be considered in deciding whether to;

      - issue an approval, preliminary certificate, or licence;
      - effect a registration; and
      - approve a transfer of an allocation under a licence and possibly apply the ability to withhold water from a transfer;

   d. adherence to the framework for water management planning; and

   e. consideration of other relevant issues.

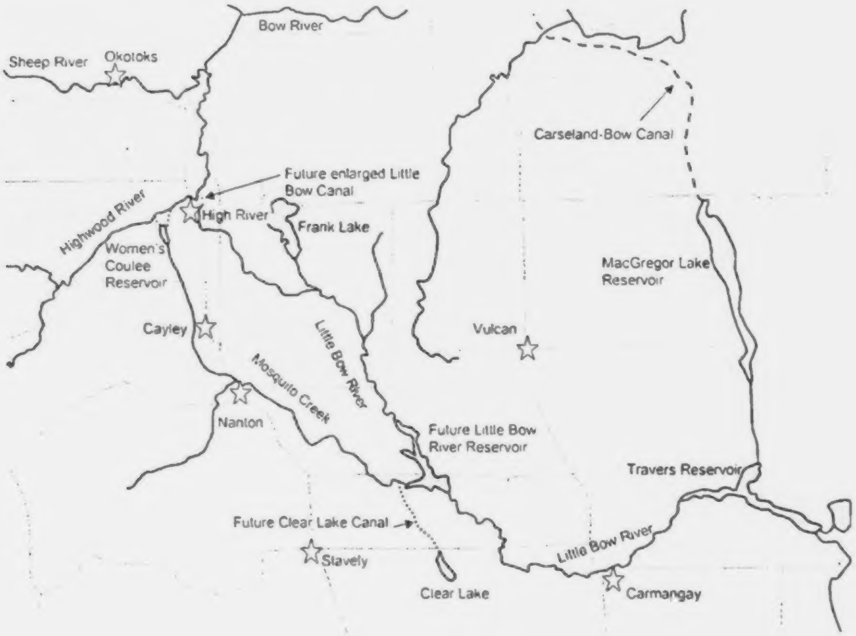
5. Public Consultation

Public consultation for the HMP will occur through a Public Advisory Committee representing stakeholder groups. Members would be appointed by Alberta Environment from a slate of candidates put forward by area stakeholders.

6. Timing

The findings and recommendations of Phase 1 of the HMP will be integrated with Alberta Infrastructure's response to the Board Order. Water management is dynamic and it is expected that changes and updates to the HMP will occur periodically.

Map of the Area


Bow River
Sheep River
Okotoks
Carseland-Bow Canal
Future enlarged Little Bow Canal
Highwood River
High River
Frank Lake
Women's Coulee Reservoir
MacGregor Lake Reservoir
Cayley
Vulcan
Little Bow River
Mosquito Creek
Nanton
Future Little Bow River Reservoir
Travers Reservoir
Future Clear Lake Canal
Slavely
Clear Lake
Little Bow River
Carmangay

Highwood Management Plan

Phasing Rationale

Alberta Environment

November, 2000

Introduction

The purpose of the Highwood Management Plan (HMP) is to develop a strategy for resolving water use issues within the Highwood River Basin. It was decided to conduct the HMP in two phases due to an immediate need to resolve issues associated with the Highwood Diversion Plan. The Diversion Plan is integral to the success of the Little Bow Project. Completion of the Diversion Plan was given a high priority by the NRCB/CEAA Joint Review Panel along with development of storage and/or non-storage options.

This report documents how issues will be handled during the HMP. It identifies which issues have been assigned to Phase 1 and which issues will be considered as part of Phase 2. The specific tasks to be included in Phase 2 will be determined in consultation with the public.

Issue Assessment

There are a variety of water use issues in the Highwood River Basin. The issues are not simple and are often inter-connected.

The key criteria in assigning issues to the phases of the HMP were:

- Can work on an issue be pursued independently from development of the Highwood Diversion Plan?
- Can work on an issue be deferred until after the Highwood Diversion Plan is completed?
- Will the issue be adequately addressed through another process?

Except for the impact of climate change, there are sufficient data or methods to assess the issues and decide on a course of action. The potential impacts of climate change on water supply and quality are not well defined nor are there suitable methods for determining those impacts in a regional context. As a result, a climate change component is not included in the HMP.

Issues related to the Little Bow Project and Highwood Diversion Plan have been included in Phase 1. Most of these issues have been identified by the NRCB/CEAA Joint Review Panel. Issues that could be deferred to Phase 2 are issues in the Sheep River Basin and issues related to land management or ground water use outside of the Little Bow River Basin.

In the case of ground water, information provided as part of the Little Bow Project/Highwood Diversion Plan EIA will be considered during Phase 1. Other ground water issues will be included in the proposed ground water management plan for the Municipal Districts of Foothills and Rocky View. When available, the results of the ground water management plan will be incorporated into the HMP.

Table 1 summarizes the issues considered and how they will be dealt with during the HMP.

Table 1

Highwood Management Plan
Coverage of Issues in Phases 1 and 2

✱ = Will be included in Phase 1 or Phase 2, or both
◉ = Option for inclusion in Phase 2.

ISSUE	Phase 1	Phase 2
Bow River Basin Impacts		
Consider the role of the Highwood Basin in the Bow River Basin	✱	
Climate Change		
Assess the potential implications of climate change	The potential impacts of climate change on water supply and quality are not well defined. It was recommended that this issue not be included.	
Fisheries Management Considerations		
Cool-water fishery in the upper Little Bow River	✱	
Examine other fisheries management options	✱	◉
Flood Protection and Planning		
Consider flood protection and planning	✱	
Ground Water		
Define aquifers	These tasks will be completed as part of a proposed ground water management plan for the Municipal Districts of Foothills and Rocky View.	
Determine sustainable yield of aquifers		
Determine water quality of aquifers		
Determine use of aquifers		
Evaluate scenarios		
Develop recommendations		
Instream Flow Needs (IFN)		
Highwood River	✱ Under review. Winter IFN will also be addressed.	
Mosquito Creek	✱ Need for IFN to be examined	
Pekisko Creek	✱ IFN evaluated as part of the Pekisko-Stimson Study	
Sheep River		✱

ISSUE	Phase 1	Phase 2
Stimson Creek	✱ IFN evaluated as part of the Pekisko-Stimson Study	
Threepoint Creek		◍
Upper Little Bow River	✱ Need for IFN to be examined	
Ware Creek		◍
Non-Structural Options		
Acceptable level of deficits	✱	
Water allocation transfer	✱	
Water conservation	✱	
Voluntary licence buy-backs[1]	✱	
Other non-structural options as identified	✱	
Riparian Management		
Upper Little Bow River Basin	✱ As required as part of Little Bow River Reservoir Water Quality Protection Plan	
Highwood River Basin		◍
Structural Options		
Evaluate storage options	✱	✱ As required
Evaluate other structural options	✱ As required	
Water Act		
Matters or factors to be considered in making decisions on approvals, licences, transfers, etc.	✱	
Adherence with *Framework for Water Management Planning*	✱	

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[1] One possible option for achieving sustainable water management is a reduction in the amount of water licensed for withdrawal. Under the *Water Management Policy for the South Saskatchewan River Basin*, Alberta Environment is committed to respecting existing licences in good standing. This policy applies to the Highwood and Little Bow River Basins since those basins are part of the South Saskatchewan River Basin. If a reduction in the amount of water licensed for withdrawal were a desirable goal, then Alberta Environment might consider a voluntary buy-back of licences to be the appropriate way to meet that goal and still respect existing licences.

ISSUE	Phase 1	Phase 2
Water Demand		
Determine existing withdrawal and consumptive use	❋ Irrigation demand under review. Demand for other uses completed.	
Determine future withdrawal and consumptive use	❋ Completed (*Non-Irrigation Consumptive Demand Projections: Little Bow Project EIA*, 1999 and *Landholder Survey: Highwood and Sheep Rivers*, 1992)	
Water Quality		
Determine current conditions	❋ Data available for the Highwood River. Monitoring continuing on the Little Bow River and Mosquito Creek.	◷ Additional monitoring proposed for the Sheep River
Determine future wastewater loadings	❋ Estimates of future point-source loadings have been prepared. (*Non-Irrigation Consumptive Demand Projections: Little Bow Project EIA*, 1999)	
Develop and apply analytical tools	❋ Predictive temperature equation under review	❋
▪ Frank Lake Water Quality Mitigation Plan ▪ Little Bow River Reservoir Water Quality Protection Plan	❋	
Water Resources Management Model		
Develop and evaluate scenarios	❋	
Water Supply		
Estimate natural flow	❋	

Appendix B, Attachment 2

Public Outreach Program to Identify and Set-up HWMP Public Advisory Committee

(Praxis Inc January 2001)

Approach to Developing the PAC

The approach to develop the HWMP will include a balanced and representative public consultation with an independent mediated /facilitated process. To assist with the process of developing the PAC, Alberta Environment retained an independent , Calgary based company called Praxis Inc. Praxis is specifically responsible for:

- Making sure residents of the Little/Bow Highwood area are aware of the HWMP process and soliciting their input regarding the PAC's composition and operation
- Proposing a structure for an effective PAC; and
- With the support of the newly created PAC, developing operating guidelines for the PAC

Praxis proposed a five-step approach.

Step 1-Public Outreach.

To inform the broadest possible public within the Highwood Basin Region of the initiation if the Highwood Water Management planning process, a public outreach process was developed and implemented in the last 2 weeks of October 2000 including:

- Mail Out – to over 800 individuals
- Flyer Drop – a call for public involvement to 18,000 mailboxes in the Highwood Basin region via Canada Post
- Posters – posted in key public facilities in the region (grocery stores, post offices, government buildings)
- Print Ads – Print advertisements in the "City" section of the newspapers in the region (Claresholm, Okotoks, Nanton, Vulcan, High River); and
- News Release - submitted to media in Highwood Basin region.

Public response to the outreach was significant with over 150 individuals registering their interest in the HWMP process.

Step 2 - Meetings with Stakeholders

A series of meetings (and in some cases telephone interviews) between Praxis and stakeholder individuals/organisations were conducted in late November and early December 2000. During the meetings, participants were encouraged to share their opinions and/or experiences with other PACs and to provide their thoughts on anything they felt was relevant including. For example: composition of PAC, the conditions necessary for to make PAC effective, the most effective structure for PAC, etc.

Step 3 – Draft Proposal and Public Feedback

A draft proposal for the HWMP PAC was developed. Those who expressed an interest in contributing to the development of the PAC received a copy of the draft proposal and had the opportunity to provide Praxis with written feedback. The feedback was reviewed and considered and , and where appropriate incorporated into the final proposal. The final proposal was submitted to Alberta Environment.

Step 4 – PAC Membership

Groups/organisations identified for membership in the PAC will be invited to submit the names of PAC members (and alternates) they have selected to represent their interests on the Committee. Individuals with no group affiliation and an interest in Public at Large membership on the PAC will be invited to submit expressions of interest to Praxis. Once PAC is functioning, PAC will determine the Public at Large is deemed appropriate, the PAC will select members based on the submissions of interest. Based on the input received, a preliminary PAC will be established. The first PAC meeting will be held in early 2001.

Step 5 – Development of PAC Operation Principles

During the initial PAC meetings, Praxis will work with the PAC to establish operating principals and guidelines, which may include, for example: convenient times and locations for meetings, the issues surrounding Public at Large membership, attendance policies, conflict resolution strategies, approach to media contact, implications of the Joint Panel Report, etc.

Appendices B, Attachment 3

Highwood Water Management Plan Public Advisory Committee Process Guidelines and Protocols

(*Approved in PAC, September 11, 2001)

***Note.** These guidelines and protocols were defined by representatives from PAC and were supported by the Alberta government and the NRCB in a workshop (August 14, 2001, High River) mediated by DSI/Ruby. Following the workshop these guidelines and protocols were ratified and approved unanimously by PAC in a September 11, 2001 PAC meeting.

1. **PAC's Internal Decision-Making**

Quorum - An official PAC meeting was defined as having a voting representative (member or alternate) from two thirds of the total number of PAC groups. Currently there are 14 groups so a quorum would require the presence of 9 groups. With out a quorum no decisions can be made nor motions passed. If a quorum attendance is not met then the participants may continue with the meeting and vote at a later meeting.

Voting – One vote per representative (member or alternate voting in place of member).

Level of Agreement Required for PAC Decisions – Level of agreement is a stepwise process (Figure 1) which applies to all PAC agreements. The process is intended to be quick and flexible.

2. **Representation**

Balance of Representation – The current balance on PAC (see Table 1 below) is acceptable, in light of PAC level of agreement process decided.

3. **PAC Operations and Structure**

Roles in Meetings – Members are eligible to vote. Alternates may vote in place of a member. Alternates speak through the member unless an alternate is requested to speak by the Chair. Observers speak with permission of the Chair. Only members are seated at the voting table. Alternates and observers are seated behind the members, for ease of communication. Alternates may take the members chair during the meeting at the agreement of the member.

Expectations – Members are expected to: consult with their constituent groups; be accountable to the constituent groups; and maintain a regular attendance. PAC is expected to provide support for members' communication with their constituents (e.g. provide a newsletter or other handout information which can be distributed).

4. **PAC Leadership Structure**

PAC will have a five person Management Committee that includes a Chairman. The Chairman acts for all of PAC and does not vote. If PAC selects a Chairman from among its members, the member group can replace the vacant seat with a new member. Final approval of the Chairman and Management Committee decisions rest with the PAC as a whole.

Interim Management Committee - PAC confirms the election of the Interim Management Committee (elected at the Workshop) to be PAC's permanent Management Committee consisting of Diana Andrews, Stephen Evans, Shirley Pickering, Gerry Porter, and Harry Riva Cambrin.

Interim Chairman - PAC confirms the election of the Interim Chairman Shirley Pickering (elected at the Workshop) to be PAC's permanent Chairman.

Secretariat – The mandate of the secretariat should be overseen by the Management Committee. The PAC can use government secretarial services if it chooses. PAC takes the option to use the government service.

Table 1. Groups and proportional representation on PAC

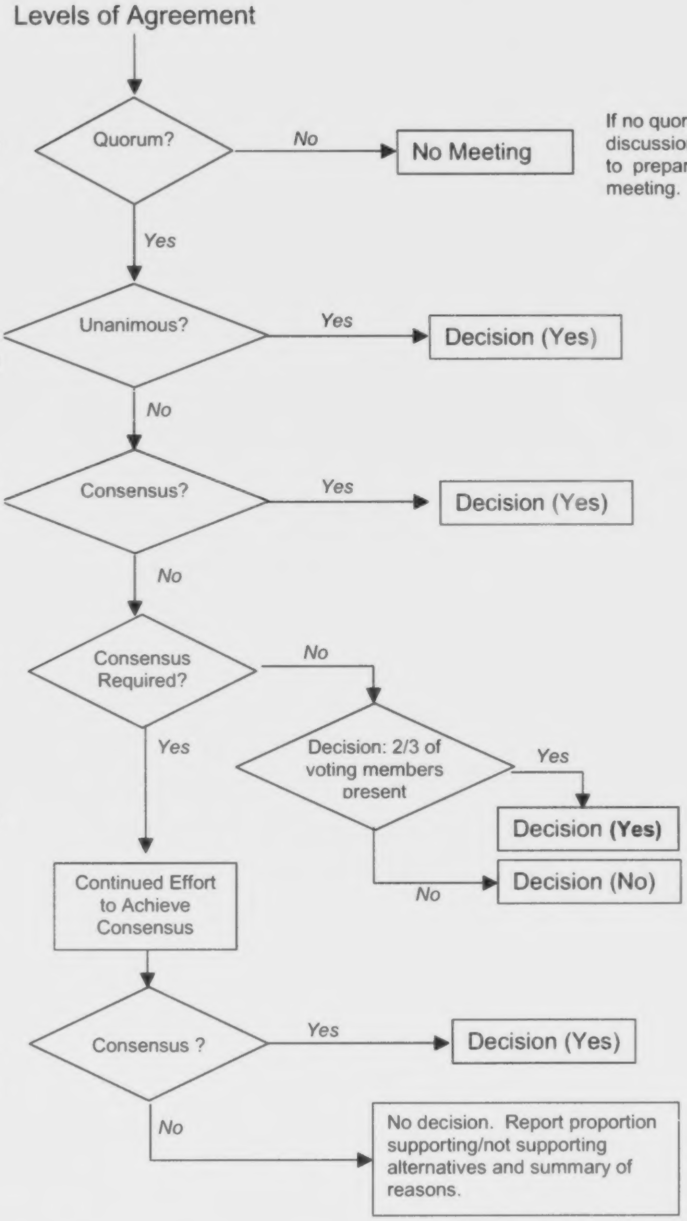
Groups Represented	Member	Alternate
Community Groups		
Lower Little Bow Basin Water Users Association	1	1
Upper Little Bow Basin Water Users Association	1	1
Lower Mosquito Creek Water Users	1	1
Lower Highwood River Water Users	1	1
Baker Creek/Women's Coulee Coalition	2	2
Tongue Creek Resident's Group	2	2
Stimson Creek Landowners' Group & MD of Ranchlands	2	2
Fisheries Coalition	1	1
Industrial Interests	1	1
First Nations	2	2
Municipal Entities		
MD Willow Creek (including Stavely)	1	1
Vulcan County (including Carmangay & Champion) & Town of Vulcan	1	1
MD of Foothills	1	1
Town of High River	1	1
Total	**18**	**18**

(September 2001)

(Attachment 3 continues to next page)

Appendix B, Attachment 3 (continued)

FIGURE 1. HWMP-PAC DECISION PROCESS


Levels of Agreement
Quorum?
No
No Meeting
Yes
Unanimous?
Yes
Decision (Yes)
No
Consensus?
Yes
Decision (Yes)
No
Consensus Required?
No
Yes
Decision: 2/3 of voting members present
Yes
Decision **(Yes)**
No
Decision (No)
Continued Effort to Achieve Consensus
Consensus ?
Yes
Decision (Yes)
No
No decision. Report proportion supporting/not supporting alternatives and summary of reasons.

Quorum is presence of 2/3 of number of groups represented on PAC

If no quorum, informal discussion can occur to prepare for next meeting.

Unanimous agreement defined as all in support - no absentions, no objections.

Consensus defined as no objections.

Consensus required if at least 1/3 of Quorum calls for it.

Ideas for developing consensus:
- Ask what would it take to join the consensus?
- Develop Hybrid if possible.
- Incorporate minority ideas to strengthen the proposed decision.
- Note concerns along with decision if necessary.

Appendix B, Attachment 4

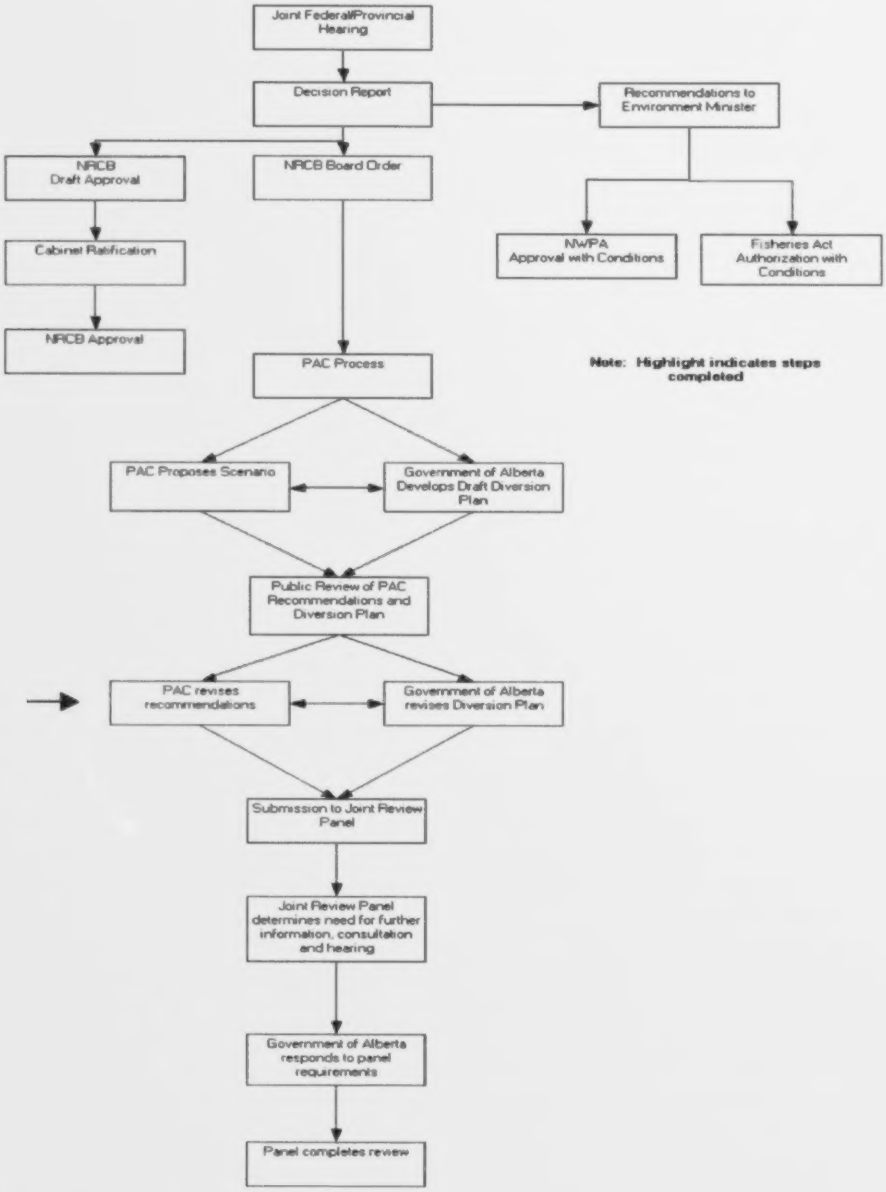
Highwood Water Management Plan Public Advisory Committee

PAC Members/Alternates List: June 2006

Community Group (Current member status)	**Representatives**
Baker Creek/Women's Coulee (Active)	Stephen Evans & Norman Smith: members Lisa Murphy & Dan Bews: alternates
Fisheries Coalition (Active)	Alan Harvie: member Kerry Brewin: alternate
Industry (Inactive as of early 2004)	Brad Walker: member Sharon Plett: alternate
Lower Highwood River (Inactive as of mid- 2004)	Grant Hirsche: member Gus Leduc Jr: alternate
Lower Little Bow River (Active)	Malcolm MacDougall: member Garry Flitton: alternate
Lower Mosquito Creek (Active)	Diana Andrews: member Ron May: alternate
Stimson Creek (Active)	Barbara & Bonnie Gardner: members Mac Blade & Blaine Davies: alternates
Tongue Creek (Inactive as of late 2004)	Phil Bice & Karin Dumais: members Colin Dumais & Maurice Walsh: alternates
Upper Little Bow River (Active)	Lucille Akitt: member Rick Janz: alternate Shirley Pickering: PAC Chairman
Municipal Entities (All Active)	
Towns/Municipalities within County of Vulcan	Dave Mitchell: member Merle Wyatt: alternate
MD of Willow Creek & Town of Stavely	Ian Sunquist: member Evan Berger: alternate
Town of Nanton	Bill Szabon: member John Blake: alternate
MD of Foothills	Roy M^c^Lean: member Harry Riva Cambrin: alternate
Town of High River	Floyd Langenhoff: member Harry Riva Cambrin: alternate

Appendix B, Attachment 5

Approval Process for Revisions to Highwood Diversion Plan


Joint Federal/Provincial Hearing
Decision Report
Recommendations to Environment Minister
NRCB Draft Approval
NRCB Board Order
Cabinet Ratification
NRCB Approval
NWPA Approval with Conditions
Fisheries Act Authorization with Conditions
PAC Process
Note: Highlight indicates steps completed
PAC Proposes Scenario
Government of Alberta Develops Draft Diversion Plan
Public Review of PAC Recommendations and Diversion Plan
PAC revises recommendations
Government of Alberta revises Diversion Plan
Submission to Joint Review Panel
Joint Review Panel determines need for further information, consultation and hearing
Government of Alberta responds to panel requirements
Panel completes review

Provided by Alberta Transportation (2004)

Appendix B, Attachment 6

PAC Process: Key Steps in Completing Phase 1 of HWMP

- Developed consensus decision-making process and operational guidelines to run a functional independent public advisory process for community-government partnership water management planning.

- Updated water supply and consumptive demand data base for the Highwood-Little Bow system,

- Participated in a government run water storage investigation in the Highwood Basin and initiated a preliminary investigations into non-storage options for sustainable water management.

- Initiated development of a water quality modelling assessment tool to assist with water management decisions.

- Assessed and recognised the revised 2001 Highwood River Instream Flow Needs criteria in developing an innovative water resource modelling approach to establish a best compromise Highwood instream flow objective.

- Adapted scenario modelling tools and developed performance assessment tools to examine and test more than 60 scenarios, in terms of aquatic environment (fishery, water quality, water quantity and riparian) and consumptive supply performance.

- Developed an innovative drought triggered component in the water resource model to predict drought impact in scenario modelling and to assist future Highwood Diversion managers with drought water supply planning in the basin.

- Achieved a consensus agreement in selecting a scenario with specified operational and future water management guidelines to serve as the basis for the development of the Highwood Diversion Plan, and to provide a baseline water balance model and assessment tools to enable completion of water management planning in the broader Highwood watershed.

- Tested Phase 1 recommendations in the broader community through 5 Open House sessions before finalising recommendations for submission to Environment.

- Documented Phase 1 recommendations in a report and submitted it to Alberta Environment to consider in its revisions to the Highwood Diversion Plan.

Appendix B, Attachment 7

Highwood Water Management Plan PAC Process Statistics

Meetings

The type and number of meetings held to operate public process between March 2001 – March 2006 are summarised below. General PAC Meeting Minutes are e-filed in Appendix A2.8 (attached DVD).

Meeting Types	Number of Meetings
General PAC	35
Task Subcommittees	22
Management Committee	40
Chairman-Government Strategy	24
Special Interest Group Consultation	04
Public Open House Sessions	05
Day Workshops	02
Total	**132**

Meetings listed above were at minimum 3 hours, except for the Chairman-Government Strategy conference call meetings (16 meetings, typically 1 hour sessions). Some Task Committee meetings were whole day sessions as were the workshops. General PAC meetings and many of the other meetings were held in the evening to meet membership timeline needs. Workshops and some of the Special Interest Group meetings were held on the weekends for the same reason.

Process Cost

Summarised below are the visible costs for setting-up and operating the PAC process. Funds allocated provided by Alberta Transportation & Infrastructure (AT&I) and Alberta Environment (AEnv) for the period during January 2001 – June 2006. The costs do not include costs for government contributed in-house technical and administration/planning services which were substantial and possibly equivalent or more.

Technical Investigations & Advice		
• Technical Subcommittee IFN		$164,968.93 (AT&I)
• Water Quality Model Development		193,364.00 (AT&I)
• Alternative Storage Options		638,543.48 (AT&I)
• Non-Storage Options Preliminary		83,000.00 (AEnv)
• Scenario Modeling Development & Performance Assessment		
-Water balance database	36,000 (AEnv)	
-Irrigation performance modeling	32,000 (AEnv)	
-Riparian performance modeling	60,000 (AT&I)	
-Water Quality performance modeling	206,822 (AEnv & AT&I)	
-Fishery performance modeling	53,233 (AT&I)	
-Technical advice & report preparation	28,306 (AEnv)	
Subtotal	⟶	416,361.00 (AEnv & AT&I)
Process Facilitation/Mediation		77,778.00 (AEnv)
Secretarial Support		7,912.00 (AEnv)
Public Consultation Evaluation		8,725.00 (AEnv)
PAC Administration & Communications		7,260.00 (AEnv)
Total Costs		**$1,597,912.41**

Appendix B: Attachment 8

PAC General Meeting Minutes

(CD file located in the pouch on inside of back cover)

Appendix C: Draft Recommendations of the Phase 1 Public Advisory Committee (September 2004)

Alberta Environment and Alberta Infrastructure and Transportation have been working toward development of a revised diversion plan under the guidance and direction of the Highwood Water Management Plan Public Advisory Committee (PAC). Computer simulation modelling was the primary analytical tool used to test numerous operating scenarios. Scenarios were developed and evaluated in an effort to find the best balance between water consumption (e.g. municipal, industry, irrigation, livestock) and environmental protection (e.g. fish habitat, water quality, riparian habitat) while staying within current water regulations.

A scenario that has been judged to meet the objectives of the Highwood/Little Bow Project, to the extent possible, has been developed. The PAC draft recommendations identify Scenario IDP8CS1 as the best compromise basis for developing the Highwood Diversion Plan. The PAC also identifies inherent measures required for implementing the plan and verifying its performance. Several general draft recommendations that the PAC believed would improve water management in the study area are also included in this section of the report. These latter recommendations came to light in the course of work on the Highwood Diversion Plan.

Recommendations

1.0 Highwood Diversion Plan Without Additional Storage

It is recommended the Highwood Diversion Plan be developed based on the attributes of Scenario IDP8CS1, which does not include additional storage in Highwood basin. Details of the storage assessment are found in the Fact Sheet: Review of Additional Storage. The key attributes, priorities and performance of Scenario IDP8CS1 are outlined in Chapter 5.0 of this report. An Alberta Environment proposed Highwood Diversion Plan (HDP), based on Scenario IDP8CS1, is available as a separate document.

The Public Advisory Committee determined the proposed HDP meets the objectives of the Highwood/Little Bow Project to the extent possible without negatively impacting pre-project water users, including the lower Highwood River fishery, and without additional storage (Super Expanded Women's Coulee Reservoir) development. The additional storage development investigated does not result in sufficiently improved performance of Scenario IDP8CS1 to justify its high cost and its social and environmental disruption.

Contingent measures or strategies for implementing and operating the Highwood Diversion Plan are essential and inseparable from the diversion plan itself. These are as follows.

1.1 Irrigation Licences with July Cut-offs

It is recommended pre-Little Bow Project irrigation licensees holding licences with July cut-offs be given a two-year opportunity to apply for removal of the cut-off by licence amendment.

In actual operation of the Highwood/Little Bow system, the irrigation licensees with July cut-offs were often granted extensions to continue irrigation after the cut-off date when the 1994 Guidelines for Highwood River Diversion and minimum operating flow targets on the Little Bow River and Mosquito Creek could be met. Scenario IDP8CS1 recognizes this water management practice by removing the cut-off date, subject to the 1994 Guidelines and to minimum operating flow targets of

0.850 m^3/s (30 cfs) along the Upper Little Bow River, 0.566 m^3/s (20 cfs) along the Lower Little Bow River, and 0.283 m^3/s (10 cfs) along Mosquito Creek. The modelling showed that irrigation performance improved over pre-project performance for these licences, and that pre-project protection of the Highwood River fishery was maintained. Also, the potential for instream flows in the Little Bow Basin from being drawn down to near zero in late summer was alleviated.

It is recommended that licensees be given the opportunity to permanently remove the cut-off date, subject to the instream conditions. There would be no change in the licence allocation or change in the priority and administration of the licences for water use prior to the cut-off date. To simplify administration and operations, it is recommended that those licensees who choose not to apply for removal of the cut-off not have their cut-offs extended in future years, regardless of the water supply situation in the Highwood and Little Bow Basins.

It is recommended that notice of this window of opportunity be forwarded to the licensees, along with application forms for amendments. It is suggested a reminder be sent out to those licensees who had not submitted an application within one year of the first notice.

1.2 Performance Monitoring for Adaptive Management

It is recommend a monitoring program and performance assessment strategy be developed and implemented to evaluate the effectiveness of the Highwood Diversion Plan in achieving the water management objectives and to provide a basis for adaptive management of the system.

PAC's work required updating the water demand and supply database to establish performance criteria for the existing diversion operations (Base Case). This task was made difficult and often thwarted by information gaps resulting from incomplete or outdated monitoring programs. Where monitoring programs were done, documentation of results were often incomplete or lacking.

The new proposed diversion plan will impose flow regime changes along the streams. Predicting the response of the complex ecosystems in the Highwood and Little Bow River Basins to this change is clearly beyond the capability of the Public Advisory Committee and its advisors. As well, the reliability of the real operation of this plan to meet water management objectives defined in the modelled scenario has yet to be performance tested. This led to the PAC adopting of the concept of adaptive management. Adaptive management requires an ability to identify and monitor parameters affecting performance, and to respond to unsatisfactory performance with corrective actions.

Systematic monitoring and assessments will enable validation of the operation guidelines, or identification of areas where operational refinements are required to minimize negative impacts on the environment and the consumptive users. Performance monitoring and assessment is recommended in the areas of water quality, riparian habitat, Highwood fishery criteria, and water use.

Development of a performance-monitoring program will require:

- Identification and co-ordination of existing monitoring programs to identify deficiencies.
- Establishing monitoring purpose, protocols and parameters (e.g. locations, timing, frequency and durations of monitoring, analytical techniques, etc.).
- Establishing the agencies and work units responsible for the monitoring and assessment.
- Preparing and reviewing interpretation reports of monitoring results on a timely basis.
- Advising the project operators and the public advisory committee(s) of findings and suggestions for operational changes.

Commitments to completing the monitoring programs and providing timely interpretations must be adhered to and done in consultation with a core group of the Phase 1 HWMP- PAC to assure responsible and accountable adaptive management decisions.

1.2a Water Quality Monitoring

It is recommended that AENV review existing water quality monitoring in the Highwood and Little Bow River Basins by all parties (Provincial and Federal Governments, industry, communities, rural municipalities, Ducks Unlimited, Trout Unlimited, etc), and develop a comprehensive, co-coordinated plan to develop a database for addressing a number of issues, including:

- **Frank Lake water quality impacts on the Little Bow River and Twin Valley Reservoir.**
- **Upper Little Bow water quality for maintenance of the aquatic ecosystem and protection of municipal, domestic, stock water, and irrigation water supplies.**
- **Mosquito Creek water quality for the protection of municipal, domestic, stock water, and irrigation water supplies. The new flow regime has significantly increased turbidity in Mosquito Creek.**
- **Determining the water quality suitability of the Twin Valley and Clear Lake Reservoirs for their respective multi-purpose uses (e.g. recreation, irrigation, source for raw drinking water, fishery).**
- **Highwood River water quality for maintenance of the aquatic ecosystem and protection of municipal, domestic, stock water, industrial and irrigation water supplies.**

Water quality monitoring must be specified in detail, efficient and tied to specific objectives. Completing the monitoring program and providing timely interpretations are required.

1.2b Highwood River Fishery Water Temperature and Dissolved Oxygen Operating Criteria

It is recommended that AENV undertake monitoring and analyses to determine the appropriateness and effectiveness of the temperature and oxygen criteria associated with operating procedures in the 1994 Highwood River Diversion Guidelines.

The validity and effectiveness of the temperature and dissolved oxygen constraints in the 1994 Highwood River Diversion Guidelines and the associated operating procedures need to be re-examined.

Temperature criteria were added to Highwood River Diversion Guidelines in 1986, and dissolved oxygen criteria were added in 1990. It was the understanding of some of the Little Bow water users that acceptance of temperature and oxygen criteria in the Highwood Diversion Guidelines was on condition that they would only be temporary constraints until measures were in place to alleviate water deficits. In the 1997/1998 EIA Hearings conducted by the Joint Review Panel, there was considerable discussion of the validity of the temperature criteria, and whether or not the resulting improved fish habitat conditions justified the negative impacts on water users in the Little Bow River Basin. Analysis and discussion was hampered by a lack of data and concrete evidence that cutbacks in diversions significantly improved Highwood River temperature conditions. Furthermore, temperature driven operations of multi-day on-again, off-again diversion cutbacks cause significant operational problems for Little Bow basin water users, as well as negatively impact water quality and the re-stabilization of riparian vegetation along the upper Little Bow River. Dissolved oxygen has not been a constraint since 1989 when treated effluent from the Town of High River was discharged to Frank Lake rather than to the Highwood River.

1.2c Riparian Habitat

It is recommended efforts be made to operate the Little Bow Diversion works in a manner that fosters a healthy riparian environment along the Upper Little Bow River. It is recommended that AENV develop and implement a monitoring and management program that tracks geomorphologic and riparian vegetation changes along the Upper Little Bow River.

It is predicted there will be geomorphologic changes along the Upper Little Bow River as the channel size and shape adjusts to the new flow regime. Once equilibrium has been reached, it has been projected there can be significant improvement in the potential for establishing and maintaining riparian vegetation. However, these predictions are not certain.

A monitoring and management program would identify and evaluate changes that occur, recommend required refinements to the operating procedures for the diversion works, and identify land use practices that would assist in establishing and maintaining a healthy riparian ecosystem. This would improve prospects for optimizing riparian benefits of the new flow regime, and minimize the negative impacts.

Riparian conditions along the Highwood River and Mosquito Creek are not expected to change significantly under post-project flow regimes. Riparian habitat improvement programs are underway in the study area. These programs should be continued, and expansion to other areas should be encouraged.

1.2d Water Use Monitoring and Reporting

It is recommended that AENV develop and implement a simple water use monitoring and reporting system to record the annual and seasonal variations in water uses and return flows in the Highwood and Little Bow River Basins.

Most licences require the water user record and report annual water use to AENV. These licence conditions have not been consistently enforced. The records that have been received by AENV have not been compiled and analyzed in recent years. Compiled, systematic water use records combined with adequate instream flow monitoring data would greatly assist in water management planning, operating the project and enforcement.

Many municipalities and industries currently record water use and return flow. For irrigation users, a simple time on/time off recording procedure and the pump rating would provide sufficient record. Water use return cards and clear instructions should be developed by AENV for the convenience of the user.

1.3 Communications

It is recommended AENV work with the water users to develop a communications system to improve the operator's ability to match water deliveries with water demands and to reduce impacts of irregularities in diversion operations.

Monitoring and reporting should be supported by good communications between operators and water users, because operators do not have perfect knowledge of water supply or demand. Users should be kept informed of operations and be alerted to irregularities, or potential irregularities, through local contact people.

In an open channel system it is not possible to perfectly match water supply with water demands. However, good communications between operators and water users will help to minimize over-deliveries due to uncertainties in day-to-day water demands and to make more efficient use of the water supply. Irrigation districts in southern Alberta have worked out water ordering procedures that could possibly be adapted to improve operational efficiency in the Highwood/Little Bow system (Appendix B). It is believed that a similar system developed in consultation with the irrigators would improve the supply-demand efficiency of the diversion system

1.4 Enforcement

It is recommended AENV enforce the allocations, and terms and conditions of licences in the Highwood and Little Bow River Basins.

The modeling results indicated many irrigation projects are under-allocated for the types of crops now grown. The farm gate demand for the types of crops grown exceeds the licence allocation in many years. PAC recommendations are based on modelling results assuming diversions cease when the full allocation has been withdrawn from the source stream. Periodic, random water audits should be conducted to ensure users are not diverting in excess of their licence allocations.

AENV administrators should be receptive to, and encourage water rationing and deficit sharing in times of deficits rather than strict adherence to the priority system. However, in the absence of a sharing arrangement, the priority system should be enforced.

Issuing temporary licences and the use of such licences requires improved compliance scrutiny. No temporary diversions should have priority over licensed uses or instream minimum flow requirements except possibly for municipal emergency use.

1.5 Role of Core Advisory Body from the Phase I Public Advisory Committee

It is recommended that a core group of the current Public Advisory Committee remain as an entity for the following purposes:

- **Oversee the timely implementation of the recommendations presented herein.**
- **Report to the Phase II PAC on Highwood Diversion Plan performance monitoring.**
- **Act as a sounding board for AENV administrators to test various ideas and options for implementation.**
- **Provide continuity and input to AENV in the conduct of Phase II of the Highwood Water Management Plan.**
- **To work with the Phase II group on setting Water Conservation Objectives.**

The wealth of information and experience gained over the past five years would be of great value in implementing the recommendations and continuing the planning program for the Highwood River/Little Bow Basins

Recommendations considered by PAC to be important for future water management in the Highwood/Little basins are as follows.

2.0 New Storage Development

It is recommended development of the Super Expanded Women's Coulee storage site or any other similar major storage in the Highwood basin not be developed to improve the aquatic health of the fishery pending further fishery field studies.

The storage performance study (Fact Sheet: **Review of Additional Storage** (Hart 2003; Compendium)) shows no real benefits to the Highwood River in developing the Super Expanded Women's Coulee storage site for the purpose of improving the aquatic ecology of the Highwood River. The hydrology of the Highwood River and the new recommended technical instream flow needs are such that there would be limited water available for diversion to storage without impinging on the instream flow needs. In low runoff years, reservoir storage would be depleted and there would be no benefits when they are most needed. The social and environmental disruption and high cost of the project also do not justify this concept (Appendix A). Other storage sites investigated by Alberta Infrastructure and Transportation (*Highwood River Alternative Water Storage Options, 2001*) were even less attractive than the Super Expanded Women's Coulee site.

PAC is concerned with the level of recognition given to the recommended technical Highwood IFN and its increased requirement for water in a basin where periodic water shortages are known. The revised technical Highwood IFN calls for substantially more water than the Fish Rule Curve-based approach originally proposed by the proponent for the Little Bow Project and reviewed in public hearings held by the Joint Review Panel. Scenario IDP8CS1 fails to meet the technical IFN due to existing license commitments, yet the modelling shows IDP8CS1 provides significant improvement in fish habitat over the Fish Rule Curve while continuing to protect the Base Case fishery conditions.

PAC, in its final selection of Scenario IDP8CS1 is vigilant in the confidence expressed by fishery experts to the technical soundness of the new IFN as an assessment tool (*Highwood IFN, Peer Review, 2001*). PAC along with some of these experts questions the validity of the IFN assessment for Highwood because of the lack of supportive observed fish and related aquatic habitat data on the Highwood system. PAC strongly believes before future consideration is given to any storage in the Highwood Basin there is need for a comprehensive fishery field study on the whole Highwood system including its tributaries to determine the value of this fishery and the validity of its aquatic habitat requirements.

3.0 Licence for the Pre-project Little Bow Diversion

It is recommended a licence for the pre-project 2.83 m^3/s (100 cfs) Little Bow Diversion be issued to the Crown in the Right of Alberta Environment.

In 1898 the Government of the Northwest Territories applied for a licence to divert 1.42 m^3/s (50 cfs) from the Highwood to the Little Bow River in NE 1-19-29-4 for domestic purposes. These works were licensed in 1905. In 1922, the Little Bow Irrigation District applied for a licence to divert from the Highwood River in NW 6-19-28-4, sufficient water for irrigation of 1335 ha (3300 acres) in the Little Bow River Basin. An Authorization was issued in the same year. The Little Bow Irrigation District (LBID) entered into an agreement with the Crown in 1922 whereby the LBID would operate its works to deliver the 1.42 m^3/s (50 cfs) entitlement of the Crown under the August 1905 licence, plus the flow required to meet the needs of its irrigators. The troublesome government works in NE 1-19-29-4 were abandoned. The 1905 licence was not transferred to the LBID and was cancelled in 1977.

The LBID experienced financial problems. In 1950 an Order-in-Council dissolved the LBID and transferred ownership and operation of the works Authorized in 1922 to the Crown. The Order-in-Council recognized that the works were intended to serve domestic and irrigation needs. The Crown made necessary repairs and improvements to the works and assumed responsibility for operations. At that time, the Crown was not bound by the *Water Resources Act*. (In 1971 the *Act* was amended to bind the Crown. Prior to this, it was assumed that no licence was required for Crown-owned works.) The pre-Little Bow Project capacity of the diversion works was 2.83 m^3/s (100 cfs). The 2.83 m^3/s (100 cfs) diversion remains unlicensed.

Licensing the 2.83 m^3/s (100 cfs) pre-project diversion would clarify ownership and the rights that exist as a result of Crown assuming responsibility for the pre-project diversion in 1922. Priorities would be ascertained. Licensing the 2.83 m^3/s (100 cfs) diversion would provide a mechanism for clarifying operation of the diversion works and providing legal status for the portion of Highwood Diversion Plan that applies to the pre-project works.

4.0 Legal status for the Highwood Diversion Plan

It is recommended the Highwood Diversion Plan be incorporated as an operation plan into Alberta Environment licences for the Women's Coulee and Little Bow Diversion works.

Incorporating the Highwood Diversion Plan into licences would give the plan legal status and a priority. Three licences would be involved: the Women's Coulee Diversion licence issued November 7, 1997, the Little Bow Diversion licence issued March 28, 2000, and a new licence proposed to be issued for the 2.83 m^3/s (100 cfs) pre-project Little Bow Diversion (Recommendation No. 3). Procedures for modifying the plan should be included as conditions on the licences, these conditions should be defined in consultation with the core Phase 1 PAC group. Modifications that significantly affect performance in meeting objectives should be subject to public review and appeal.

5.0 Licensing Post-Little Bow Project Water Use

It is recommended that AENV continue to license projects using water from, and downstream of, the Twin Valley Reservoir in accord with the application and priority system under the *Water Act*. Licensing should not be limited solely to irrigation; other uses to consider include municipal, industrial and other agricultural. Total allocations for all uses should not exceed the amount of water required for the irrigation of 6677 ha (16,500 acres). The moratoria that adhere to the scenario instream guidelines should remain in place on the Highwood River, Upper Little Bow River and Mosquito Creek until Water Conservation Objectives have been established.

If real operation of the HDP is to be performance assessed it is important that instream guidelines be recognized in allocating new licensing, including temporary licenses. The documentation on the existing moratoria is sparse and unclear on instream guidelines for conditions of licensing under the exemption clause. If the existing moratoria is to be revised applied to the Highwood/Little Bow basin adherence to the scenario instream guidelines must be required to assure water management objectives are met. It is therefore recommended that in the future licensing new water right applicants for any purpose must be made aware of the magnitude and frequency of risk of water supply deficits that can reasonably be expected. Informed Applicants should be given the opportunity to withdraw their application, modify their project or proceed with the project as per their application.

6.0 Cancellation of Inactive Licences

It is recommended AENV cancel water licences that have not been used for a period of at least three years, and where there is no reasonable prospect for exercising the rights granted under the licence. The water should not be reallocated.

Unused allocated water creates a condition of uncertainty in a basin. If administrators do not know if or when the project will be activated, planning for economic growth and environmental protection is compromised.

It is essential that cancellations be implemented only where justified, and only after due process. Cancellations will be subject to appeal by the licensee.

7.0 Licence Allocation Transfers

It is recommended licence allocation transfers (entire or partial) of mainstem Highwood River, Mosquito Creek, or Little Bow River water be permitted only after review of factors listed in the *Water Act*, and under the following additional conditions:

- **The seller and buyer are on the mainstem streams in the same sub-basin (Highwood River, Upper Little Bow, Lower Little Bow and Mosquito Creek or Women's Coulee). For example, if the seller's licence is on Mosquito Creek, the buyer's licence should also be on Mosquito Creek.**
- **A licence supplied primarily from stored water should be transferred to a buyer who will be primarily using stored water for the license.**
- **There is no adverse impact on environmental quality or other water users on the affected stream reach.**
- **Public input is always sought, the minimum effort in this regard being advertising the application in local newspapers.**

Water allocation transfers and holdbacks in the South Saskatchewan River Basin were approved in Phase I of the South Saskatchewan River Basin Water Management Plan (AENV 2002).

The primary objectives for permitting transfers in the Highwood/Little Bow study area are to provide an opportunity for new users or existing users requiring additional water to obtain a licence in these fully allocated basins, and to contribute to instream needs through holdbacks. It must be recognized that in the water-short streams of the Highwood/Little Bow River basins, a downstream licence allocation serves purposes beyond that of the licensee. A downstream allocation contributes to upstream flows, and improved water quality and riparian conditions. These benefits would continue if the transfers remain on the same mainstem reach. Downstream transfers are preferred, however, some upstream transfers may also be acceptable. Transfers for like purposes would probably minimize impacts on the stream and other users, however, transfers for unlike purposes should not be ruled out where they have minimal impacts and provide benefits.

8.0 Highwood River Water Conservation Objectives

It is recommended that establishing Water Conservation Objectives on the Highwood River, Upper Little Bow River and Mosquito Creek be further explored.

The PAC supports the concept of Water Conservation Objectives protection of the aquatic environment of the streams, and as receptacles for licence transfers and holdbacks. However, as previously discussed above, the PAC remains concerned about the validity of the new science based Highwood IFN and its increasing demand for water. Assigning a WCO that meets this IFN could shut down the basin for further water licensing in a community that is under increasing development pressure. For this reason PAC feels that it cannot assign a WCO to the Highwood River until a more comprehensive and integrated approach to establishing WCOs in the entire Highwood/Sheep/Little Bow system has been undertaken. It is further recommended such an investigation be given a high priority in Phase II of the Highwood Water Management Study. In the meantime, moratoria similar to the existing moratoria should be established for the Highwood River Basin, Upper Little Bow and Mosquito Creek. Licences for exempted uses should be subject to instream objectives and flow targets defined in the Highwood Diversion Plan.

9.0 Highwood Water Management Plan – Phase II

It is recommended AENV proceed with Phase II of Highwood water management planning. The Phase II study should include, but not be limited to:

- **An integrated and validated instream flow requirement study of major streams and tributaries in the Highwood/Sheep/ Little Bow system to assist in the establishment of instream Water Conservation Objectives.**
- **Track monitoring assessments on Highwood Diversion Plan performance.**
- **Sheep River water supply and environmental issues.**
- **Groundwater issues and the relationships between surface water and near-by groundwater.**
- **Continue investigations into non-storage water management options.**

The issues identified are those that have been raised by the PAC in the course of conducting he Phase I study on the Highwood Diversion Plan. They are not considered to be all-inclusive.

Appendix D: Irrigation Water Ordering Procedures

Irrigation districts in southern Alberta are making a concerted effort to improve efficiencies and conserve water. Most of the larger irrigation districts have placed an emphasis on reducing return flows. Water ordering procedures that enable operators to better match water deliveries and water demands are a significant component of efforts to reduce return flows.

The following water ordering procedures were taken from the St. Mary River Irrigation District June 2004 newsletter, "The Head Gate".

Water must be ordered on and off. Ordering the water both on and off allows the Water Supervisor to make the most efficient use of the water in the system and reduce wastage.
Water must be ordered on by contacting the Water Supervisor prior to noon at least 24 hours prior to the time water is required.
Water must be ordered off by contacting the Water Supervisor at least 24 hours prior to the time delivery is to be stopped.
Delivery changes will be made Monday-Friday. Saturday delivery changes are at the discretion of each Water Supervisor and may be possible if the water is in the system.
Water must be taken in an initial 24-hour increment and 12-hour increments after initial 24-hour period.
The full notice of 24 hours is required for shutdown due to high winds or low temperatures. Delivery can be cancelled for mechanical breakdowns, with immediate notice to the Water Supervisor.

Appendix E: Glossary of Commonly Used Terms

Allocation	Water approved by Alberta Environment for a use other than for household purposes (use by an owner of property adjacent to a water body or aquifer), it is referred to as an allocation. An allocation is described by the volume, rate, timing and conditions (restrictions) for a diversion of water.
Aquatic ecosystem	An aquatic area where living and non-living elements of the environment interact.
Aquatic environment	The components of the earth related to, or living in or located in or on water or the beds or shores of a water body, including all organic and inorganic matter, and living organisms and their habitats, and their interacting natural systems.
Consumptive use	Water quantity of water taken from a source that is not returned to that source.
First-in-time, first-in-right	The principle used to prioritize water rights in Alberta. This principle has been in place since 1894. It gives priority to older licences regardless of purpose. The older the licence is, the higher its priority.
Headwaters	The source area of a stream.
Infrastructure	Physical facilities, such as canals, reservoirs, pipelines and treatment plants.
Instream flow	The rate of flow in a river without reference to its purpose.
Instream flow needs (IFN), or Instream needs (IN)	Scientifically determined amounts of water and water quality conditions needed to sustain riverine processes and associated ecosystems over the long term.
Instream objective (IO) or minimum flow	Flows that are to be maintained in a stream as a result of dam operations or by restrictions on licences to provide some level of protection of the aquatic environment.
Natural flow	The flow that would be in the stream in the absence of man's influence. It is often a calculated value based on recorded flows and diversions and uses.
Non-consumptive use	A use of water that does not affect the amount of water remaining in a water body, such as an instream use or a withdrawal use that is completely returned to the source stream.
Potable water	Water fit for human consumption.
Return flow	Water that has been withdrawn from a water body and is returned unused or after it has been used.
Riparian area	The areas along water bodies where water and land interact.
River basin	The land area that contributes surface water to a stream.

Sub-basin	A portion of a river basin that contributes water to a tributary stream.
Water Act	Alberta legislation that governs the allocation of water and protection of water and its ecosystem.
Water allocation transfer	All or a part of a licence allocation that is transferred from a licence holder to another water user by agreement. Water transfers can occur only if authorized under an approved water management plan, or if approved by the Lieutenant Governor-in-Council. Alberta Environment must approve the transfer. When a transfer is made, the original licence is cancelled and a new licence is issued to the new water user with the same priority as the transferred licence.
Water conservation holdback	If authorized under an approved water management plan, or if approved by the Lieutenant Governor-in-Council, the Director has authority to withhold up to ten percent of an allocation of water that is being transferred if he feels that withholding such water is in the public interest to protect the aquatic environment.
Water conservation objective	The amount and quality of water required to protect a water body or its aquatic environment, or any part of them.
Water licence	Authority under the *Water Act* for diverting and using surface or groundwater. The licence identifies the source, the location of diversion and use, the maximum amount of water that may be used, the priority of the water right, and the conditions under which the diversion and use may take place.
Water quantity modelling	A mathematical analysis that computes streamflows, diversions, canal flows, water uses, reservoir water levels and performance in meeting demands under various water management scenarios and for a variety of streamflow and climatic conditions. Modelling is used extensively in water management planning.

Highwood Water Management Plan

Phase I: Highwood Diversion Plan

Appendix F: Unit Conversion Factors

SI Units (metric)	Imperial Units
Area	
1.0 hectare (ha)	= 2.471 acres
1.0 square kilometres (km^2)	= 0.386 square miles
Length	
1.0 millimetre (mm)	= 0.039 inches
1.0 metre (m)	= 3.281 feet
1.0 kilometre (km)	= 0.621 miles
Volume	
1.0 litre (l) = 0.001 cubic metre	= 0.0353 cubic feet
1.0 cubic metre (m^3)	= 35.315 cubic feet
1.0 cubic decametre (dam^3) = 1000 cubic metres	= 0.811 acre feet